THE
POPULAR SCIENCE
MONTHLY.

FEBRUARY, 1911

THE DISCIPLINARY VALUE OF GEOGRAPHY

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Part I. The Science of Geographical Investigation

Educational Values.—Any study that is worthy of a place in a university must have a value of its own, must stand in a serviceable relation to other subjects, and must offer a serious mental discipline for those who follow it. The modern treatment of geography by explanatory instead of by empirical methods, and in view of an evolutionary instead of a teleological philosophy, satisfies all these requirements. That geography has a value of its own is sufficiently indicated by the abundance of useful and interesting material that an otherwise well-prepared student may acquire from it, and from no other source. That it stands in a serviceable relation to other subjects is proved by the fundamental position that it occupies with respect to biology and history, as well as to commerce and diplomacy. That it provides a serious mental discipline will, it is hoped, be apparent to any one who cares to read the following pages. A discussion of the science of geographical investigation, here presented with particular respect to the study of land forms, but equally applicable to other divisions of the subject, will show that geography, like various other sciences, gives abundant exercise to various mental faculties, such as observation, invention, deduction, comparison and judgment; while a consideration of the art of geographical presentation will show that geography, like other sciences, encourages the development of various styles of composition, such as narrative, inductive, analytical, systematic and regional, each of which is particularly well adapted to the exposition of certain geographical problems.

The Student and the World.—It has been well remarked by an experienced university professor, that an advanced student would profit

greatly if he guarded himself against a too great absorption and isolation in his investigation of a limited field of study, by giving conscious attention to the presentation of his results in the best possible form for their full appreciation by so many of the rest of the world as may be interested in them; for he would be thereby placed in a more sympathetic relation with at least some of the rest of humanity, from whom he might otherwise remain too long estranged. Success in this effort is greatly promoted if the student recognizes the essential differences between investigation, which tends to isolate him from the world, and presentation, which ought to bring him into relation with it. The chief of these differences may be here pointed out, with particular relation to geographical problems.

Investigation.—During the progress of an investigation the student is properly enough alone with his subject for a large part of his time, whether he is in the field, the laboratory or the library. This is quite as it should be, for if during this period his attention is much distracted by outside matters, he can not develop a single-minded concentration of his best efforts on his work; he can not form that close intimacy with his problem which comes from uninterrupted association with it. Several weeks or months may be devoted to reaching his conclusions, and during this period the student may rightly enough find himself increasingly absorbed in his work and correspondingly withdrawn from outside relations; but he must remember that isolation does not involve secrecy. The pleasure of progress and discovery is increased by sharing it with appropriate companions. If some ideas are thus planted in better soil than that from which they sprang, let the larger growth that they reach there cause rejoicing, not envy; for as Gilbert has so well said in an admirable essay on "Scientific Method": "It is only the man of small caliber who has no ideas to spare, and secretiveness in matters of science is ordinarily a confession of weakness."[1]

In the course of progress, facts and theories are come upon in an irregular and unforeseen order; only towards the close of his work is the student in a position to reconsider everything that he has learned and to give it all a well-ordered arrangement. During his advance he must ever be alert in discovering new facts, open-minded towards new ideas, critical of every statement, jealously watchful of his mental independence, judicial in reaching conclusions: but in all these activities, his work should be carried on for the most part alone, for only when isolated is he sufficiently thrown on his own resources; and only when thus depending on himself can he learn whether he is really able to carry on an independent investigation. His opinions may fre-

[1] G. K. Gilbert, "The Inculcation of Scientific Method by Example," *Amer. Journ. Sci.*, XXXI., 1886, 284–299.

quently change as his collection of facts and his invention of explanations advance; new facts and new ideas may frequently call for the revision of earlier facts and ideas, and for the change of first-formed opinions; all such revision and change are best accomplished when the student is alone with his problem. At the end of his study, the net results gained may appear to be of small volume, in view of the time and labor spent in reaching them; but if they include a matured and well-balanced judgment on the problem under discussion, as well as an intimate acquaintance with its sources of material, a comprehensive knowledge of its historical development, and a close familiarity with all the factors involved in its investigation, the time and labor will have been well expended.

Presentation.—Occasion then arises for the oral or printed presentation of the results of all this independent work, in form for their best understanding by others. The student must then emerge from his isolation, in which the world may have seemed to him to be occupied chiefly by his problem and himself; he must recognize that the real world is crowded with other problems and other workers, among which he and his interests may be rudely jostled in course of finding the place that they deserve. He must now awake to a realization of his surroundings, and consider particularly what sort of presentation will place his results most effectively and favorably before the public. He no longer has to consider the nature of his own work; that he has done sufficiently already. He has now to consider the nature of other persons whose interests are more or less akin to his own, in order to discover how he can best bring his work before them. When his presentation has been made, he will learn that those of his hearers or readers who meet him with unselfish sympathy and just appreciation become his most helpful and encouraging friends; and he ought at the same time to learn what his own bearing should be when it is his turn to listen to reports by his colleagues on their work. We will here examine briefly the requirements of an oral presentation, postponing the discussion of a printed report to a later page.

When a student rises to make an oral report in the presence of his teachers and his comrades, he is no longer an investigator alone with his problem; he takes his place as a speaker, between his problem and his hearers. There may be cases in which his personal experience deserves narration; but in scientific communications, personal items should, as a general rule, be relegated to the background; the speaker had best try to obliterate personal matters, which always give a more or less subjective flavor to a report, and strive to make himself simply the conduit through which the essence of his subject, in the most objective form, shall flow to the minds of his hearers. He has no longer abundant time, but is limited to half an hour, or an hour at the most; at

the end of which time his audience ought to have acquired the gist of what has taken him weeks or months to learn. Evidently then the speaker must present only a selection of his best facts, theories and conclusions, in the most carefully planned order. He must say nothing at all about much of the material that he has gathered; he must touch very lightly and briefly on various subordinate items, and he must bring forward only those statements for fuller presentation which bear most significantly on his problem, and which can as far as possible be easily understood and remembered by his hearers. For this purpose he must, of course, before he begins to speak, know what grade of audience he is to address: for however useful the exercise of merely addressing an audience may be to an inexperienced speaker, whether what he says is understood or not, he must remember that an audience which has listened for half an hour or more and learned little, has wasted its time. A courteous consideration of those present, as well as a selfish regard for the opinion they will form of him and his work, should lead the speaker to make every effort to repay them for their time and attention, by making his presentation as intelligible and interesting as possible. He must therefore strive to produce a clear and definite understanding of his results in the mind of each hearer, in such form that a good share of them can be carried away and remembered. Hence it is not only on the ground of a generous consideration for the feelings of his audience, but, as above said, also from a selfish interest in his own progress, that he ought now to strive to make himself clearly intelligible. If he does not do this, he will be like an unsociable gold-washer, who, with patient endurance, has worked over a great volume of gravel for the sake of finding a few grains of gold, and who then, instead of having the gold refined and coined in form for current circulation among his fellows, keeps it in the comparatively useless form in which he found it; and at the same time complains that the value of his patient work is not recognized.

In view of all this it is manifestly desirable that a student should give due attention to the presentation of his results, as well as to the methods of investigation by which the results were gained. He will be aided in both these worthy efforts if he recognizes clearly the striking differences between the two processes, and then gives to each process the attention necessary to its best development. An analysis of the method of investigation, as applied to the study of land forms, here follows. A fuller statement regarding presentation will be given in a second article.

Analysis of Investigation.—As long as geography was concerned only with the observation and record of visible facts, its methods were relatively simple. They included, as far as land forms are concerned, the determination of latitude and longitude, the measurement of direc-

tions, distances and altitudes, and the preparation of maps of appropriate scales, along with an empirical description of the facts observed. For those geographers, however, who, in these modern days, enter whole-souled into the explanatory method of describing land forms, there is needed, in addition to all the earlier requirements—for every modern geographer ought to be well exercised in the preparation of empirical descriptions, as well as in the arts of surveying and cartography—a careful and conscious training in theoretical investigation; because every explanatory description, in so far as it introduces the supposed facts of the past as the best means of describing the visible facts of the present, goes beyond observation and employs theories; and theories can be successfully established only by the critical use of scientific methods of investigation.

The different mental processes involved in an investigation of the kind with which we are here concerned may be arranged as follows: observation and record of accessible facts; induction of generalizations; search for fuller explanation; invention of hypotheses or supposed mental counterparts of invisible facts; deduction of consequences from each of the invented hypotheses; confrontation of the consequences with appropriate facts; preliminary judgment; revision and improvement of each process; final judgment of the degree of correctness of various invented hypotheses.

Observation and Record of Accessible Facts.—The first step in a problem is the acquisition of a certain number of facts. This may involve original observation, as in the outdoor exploration of a geographical field, or it may be based on second-hand observation, as in the study of some other observer's records in books and maps. In either case, the investigator must be alert to avoid deception by mistaken appearances and by misleading subjective sensations; at the same time the mind must be kept sensitive to every real impression, to which it must respond in the most docile manner, submissively recognizing the facts as they stand, not constraining them in the least one way or the other. The investigator must be untiringly active in traversing his outdoor field, and omnivorous in devouring all pertinent material in the library. Indeed during the process of acquisition, outdoors and indoors, the investigator's mind must be like a fresh and sensitive photographic plate, on which no previous impressions blur the new ones that are made on it.

The facts mentally acquired must in some way, graphic or verbal, be recorded; and at the outset the records should be made in colorless empirical form, as free as possible from theoretical prepossessions. It will be chiefly in proportion to the larger or smaller measure of previously acquired experience that the observer will, at this early stage of his study, employ roundabout phrases or technical terms in recording

the facts that he comes upon. If he says: "That is a promontory," this simple empirical statement implies that he sees a certain configuration of land and water, and recognizes that it possesses the essential features of a typical configuration already known from previous experience, for which the empirical term, promontory, has been adopted by general consent. But if he says: "That is a delta," the statement involves some measure of theory. It implies, as before, that he sees a certain number of features in the land form before him, and that he recognizes their correspondence with the essential features of the concept or type, for which the name, delta, has been agreed upon; but inasmuch as a delta is the product of a certain process acting under certain conditions through some unobservable period of past time, the observer has here made a leap into theory, although he may be hardly aware of it. As soon as such a leap is recognized, the visible features of the land form before the observer should be reexamined and stated for the time being in purely empirical terms; that is, in terms based on what is immediately seen, instead of in part on what is inferred. All this calls for fair-minded deliberation, the development of which demands time and training. If this cautious procedure seems slow and cumbersome, it should be practised with respect to various explanatory terms now commonly in use, such as delta, dune, volcano, moraine and so on, until it can be performed with ease and speed. During the progress of such training, a few examples of this elementary kind of analysis should be written out *in extenso* in the investigator's note book. The number of pages of careful records may at this time serve as a better measure of progress made by a young geographer than the number of miles traversed over hill and valley.

Induction of Generalizations.—When new facts are encountered they are, as has just been shown, more or less consciously compared, in the way of likeness or contrast, with acquisitions of previous experience. As progress is made, groups of similar facts are formed, the several members of a group being alike in respect to certain features that are therefore taken to be essential. An active-minded student quickly generalizes the repeated features by which all the observed members of a group are characterized; thus he conceives an idealized type; and at the same time relegates individual features to a lower rank. As new facts fall into groups already formed and give further warrant for the provisional generalizations previously made, a careful phrasing or formulation of the generalized features should be attempted, with some mention of the way in which individual examples depart from the idealized type. Thus an advancing investigation passes from the recognition of separate facts to the induction of generalized ideas. Certain classes of facts are so fully accessible to observation that the generalizations induced from accumulating records suffice to provide a reasonable

understanding or explanation of the phenomena concerned; for example, the work of the wind in sweeping sand across a desert and whirling dust high into the air may be seen in operation; or the behavior of rivers in draining their basins and in transporting land waste may be closely studied by direct observation: hence wind action and river action may in these respects come to be understood by induction alone. But the larger action of these agents, as in the erosion of elaborate valley systems by rivers, and in the sculpture of peculiar desert forms by the winds, demand much unseen work in long past time; and even if induction on a widely extended basis could ultimately bring forth the full explanation of such problems, the mind is too impatient to wait for so long postponed a result, and seeks other means of reaching the same end.

Search for Theoretical Explanation.—One sometimes meets inductive investigators who say that they believe it best not to enter upon the speculative aspects of their work, even in complicated problems, until all the facts have been gathered; but such caution is unwise, even if it be mentally possible in one who is capable of conducting an original investigation. An unintelligent person may indeed see various outdoor facts, and continue to observe, collect and record them, and yet never ask himself or anyone else about their cause; but such a person is not mentally fitted to undertake the investigation of new problems, such as are here considered. On the other hand, when an earnest investigator comes upon facts of a complicated nature, he can not help wondering how they came to be what they are; he is not satisfied with the slow progress of induction toward their explanation; he inevitably feels some curiosity as to their invisible origin, that is, as to so much of their history as has already passed; he is discontent to remain ignorant; his mind is alert to find hidden meanings, just as his eyes are watchful to see visible features. He wishes to know about past facts which, in their time, were as veritable as are the facts of to-day, and which taken with to-day's facts assume that reasonable relation which we call explanation. This is precisely as it should be. If by good fortune the student's wonder and curiosity are so much aroused by what he sees, that they excite the invention of a possible explanation for his novel facts, the part of wisdom is surely not to turn his mind away from this invention, which may prove to be an extremely useful one, but merely to refuse immediate belief in it, before its value has been tested. The danger here lies not in the wish for explanation, nor in any ingenious invention of an explanation, but in the acceptance of such an invention as if it were the final truth. That is truly a serious error; an error that is not to be guarded against by stifling the inventive faculty, but, as will be shown below, by arousing the critical faculties to a rigorous examination of any suggestions that the inventive faculty may bring forth.

Invention of Hypotheses.—The search for explanation of observed facts may be made in some cases by the memory, which may recall an explanation previously learned. In physics and chemistry, the search for explanation is largely aided by experiment; but in the study of land forms experiment serves chiefly to illustrate explanations already reached, rather than to lead to new ones. We are here chiefly concerned with the kind of search which calls the investigator's own faculty of invention into play—the kind of search which tries to make a new combination of some pertinent facts or principles of previous acquisition with some of the facts of new observation, in the hope of thereby bringing about a clear understanding of all the facts under discussion.

The faculty of invention is peculiar in working to a large extent subconsciously. Facts to be explained can be intentionally observed; previously gained knowledge may for the most part be consciously reviewed; but the desired explanatory combination of old knowledge and new facts may not be immediately found while the conscious search for it is going on. Invention is, however, much favored by active observation, and spurred on by an eager spirit of inquiry; it is greatly aided by mental ingenuity, but it is seldom immediately accomplished by conscious intention. However, the faculty of invention can be cultivated if many facts, old and new, are frequently brought to conscious attention, and the wish for explanation and the search for it are often renewed. Then the subconscious mind will continue the search, and after an interval, during which the matter has been apparently out of mind, an explanation may most unexpectedly awaken attention by springing into consciousness.

The sudden birth of an apparently successful explanation is truly a most delightful experience; indeed so delightful and encouraging that many an investigator has mistaken it for the climax or crown of his work, and accepted it as the whole truth without further question. But, as has already been pointed out, the too-ready acceptance of an untested invention, as if it were true, is dangerous. The investigator must recognize that it is no great recommendation of an invention, that it explains the partial group of facts that it was made to explain. Of course it must do that; it would deserve no consideration at all if it did not. But in order to deserve acceptance as the true counterpart of past facts, it must do much more. It must explain various facts that it was not made to explain; facts that it did not expect to explain; facts that were not thought of, or were not even known at the time of invention, as will appear more fully below.

The investigator of course hopes that his invention, based on some of the observed facts, will prove to be the true counterpart of some past facts, or of some invisible principle or process, by means of which

he shall gain a full explanation of all the observed facts; that is, an understanding of the manner in which they have been produced. While the invented counterpart remains of uncertain value, because untested, it is often called an hypothesis; and its uncertainty may be further indicated by calling it a provisional, or a working hypothesis. If later on, it survives all the tests that can be applied to it, it is then usually called a theory; or in order to emphasize its proved value, an established theory. But it is never, so far as the unseen facts of the past are concerned, anything more than the mental counterpart of those facts. Indeed, inasmuch as an hypothesis, when first invented, is usually based on only a few of the observed facts, it will then be only the counterpart of a few of the facts of the past, or of some general principle that suggests the genetic relation of partial groups of facts, past and present. Much more than the mere invention of such an hypothesis must be done before a complete explanation of all the facts is reached; and it is through the additional work, by which supplementary facts and fancies are correlated, that an invented hypothesis is tested.

As soon as the tentative nature of an hypothesis is understood and its possible failure is recognized, the investigator should realize that he must not stop inventing when his first hypothesis is brought forth; he must urge his subconscious mind to continue bringing forth inventions as actively and ingeniously as possible. He must thus equip himself with several rival working hypotheses,[2] to each of which he must give warm welcome and impartial friendship, but to none of which must he offer special protection or advocacy. The defence for a hypothesis is provided chiefly from new details that are added to it after its invention, or by new facts which are brought to light by its aid. If no defense of this kind is found, the hypothesis must be regarded as only a tentative speculation.

Deduction of the Consequences of an Hypothesis.—Before any decision as to the truth of a hypothesis is attempted, the question must be asked: What consequences must it have in addition to those facts which it was made to explain? An altogether new faculty is now called into play, the faculty of deduction, by which the consequences of a hypothesis are logically worked out. Here again experimentation is extremely useful in physics and chemistry, and it is coming to be more useful than it has been in biology and geology; but in the study of land forms experiment is at present rather imitative than demonstrative, and it will not be further considered here. What we have to examine now is a logical faculty that can be more consciously used than invention, but one which, unlike observation, can be carried

[2] T. C. Chamberlin, "The Method of Multiple Working Hypotheses," *Journ. Geol.*, V., 1897, 837–848.

on in the dark with the eyes shut. During the exercise of this faculty the investigator must in the most critical manner and with the aid of all necessary pertinent knowledge, think out or deduce everything that would happen, if an invented hypothesis were really true; and this he must do for each hypothesis in turn. The consequences appropriate to each hypothesis must be kept in groups by themselves; and these groups of hypothetical consequences must be carefully distinguished from the facts of observation.

In a geographical problem, the investigator must mentally search out, in view of each hypothesis that he has invented, the whole sequence of changes that would take place, the whole sequence of land forms that would be developed, if the class of forms with which he is dealing were followed all through its history, past, present and future. No invention should be hastily discarded, because it appears at first sight to be improbable; for such appearance may be more determined by the scientific fashion of the time, or by the mental habit of the investigator, than by anything inherent in the invention itself. Particular attention should be given to the deduction of unlike consequences of rival hypotheses; for, as will soon appear, it is particularly by means of these *instantiæ crucis* that successful and unsuccessful hypotheses are discriminated. Those who find deduction irksome should be advised to practise it until it becomes easy and agreeable; just as careless observers should be urged to continue observation until they can perform this fundamental process with accuracy and enjoyment. In no case should an investigator, particularly an unpractised investigator, put his trust in that rapid mental process called intuition, and hope by its uncertain aid to leap from invention to conviction. Let intuition be welcomed, just as invention is; but after it has leaped to its goal, its half-conscious path should be carefully retraced and the safety of its leap tested.

Confrontation of Consequences with Facts.—We now reach a stage in which the faculty of impartial comparison is brought into play. Facts have been gathered abundantly by the active observer, who is still at work gathering yet more of them; hypotheses have been brought forward in good number by the ingenious inventor, who is, however, still at work in the hope to find new ones; the consequences of each hypothesis have been carefully worked out, group by group, by the patient and logical deducer, who stands ready to elaborate the consequences of new hypotheses as soon as they are found; and the consequences are now to be confronted, group after group, with the facts by the impartial comparer, in order to see how close an agreement they reach. This is as if the observer should marshal his battallion of facts in good order on one side of a parade ground, and the deducer should lead forth the battalions of consequences one after another and halt them opposite the marshalled facts, so that the comparer could to best

advantage inspect the opposed arrays, with the intention of seeing how closely any battalion of consequences matches the battalion of facts. In making this inspection, the comparer must evidently give particular attention to the facts from which an invention did not spring; and look closely to see how successfully they are matched by the consequences of the invention. There must be no pressure to force an agreement where none exists; no constraining of the facts or torturing of the consequences to make them look like each other; but simply a fair-minded comparison, followed by a clear unbiased report as to where agreement and disagreement occur.

Preliminary Judgment.—If two rival hypotheses have yielded only identical consequences, all of which agree nicely with the corresponding facts, no decision in favor of either hypothesis can be made, and judgment must be suspended. The comparer must then ask the deducer if he can not find unlike consequences of the rival hypotheses; and if such are found close attention must be given to the degree of success with which they match the corresponding facts. Evidently, then, some consequences have a greater value than others in discriminating among rival hypotheses. If the consequences which are peculiar to one hypothesis match the appropriate facts, while the contrasted consequences of other hypotheses fail to do so, then a higher value may be given to this one of the several rival hypotheses, although before it had no greater value than its now defeated competitors.

Revision.—It will often happen, when confrontation is made and an encouraging amount of agreement is found between the consequences of a certain hypothesis and the corresponding facts of observation, that the agreement is nevertheless in some respects imperfect. It may be that, for some of the facts, no corresponding consequences have been deduced; or that, for certain deduced consequences, there are no corresponding facts. Then the investigator must revise his work. He must return to the stage of deduction, and look closely to see if those consequences which are only partly successful in meeting the facts, were rightly deduced; he must inquire if the absence of a certain consequence, with which some well ascertained fact ought to be matched, is perhaps due to oversight in his deduction. He must examine with particular care all the principles, introduced by memory from previous acquisition, to see if they are safely established and correctly applied; he must be especially careful not to overlook any tacit postulate, which, without being consciously recognized as such, has nevertheless been taken for granted without sufficient proof, and used as an essential basis for some of his deductions. He must go still farther back and modify his inventions in one way or another, in the hope that, after such modification, some one of them may lead to new consequences that will better than before fit the previously unmatched facts: hence it is im-

portant to regard each invented hypothesis as an elastic conception, whose form may be changed as necessity demands. The investigator must even return to his field of observation and reexamine the facts, particularly such as do not match with the well defined consequences of a partly successful hypothesis; and he must search his field with the sharpest scrutiny to see if any facts, previously unnoticed, really do occur in the manner indicated by unmatched consequences. In every way, the utmost care must be taken not to allow oneself to be satisfied with imperfect or incomplete agreements.

If these various recommendations are carefully carried out, the danger, often feared, that an investigator may, Procrustes-like, force the facts to fit the needs of a favorite hypothesis, is practically ruled out; for if the investigator has several unlike hypotheses in mind, and has deduced several unlike series of consequences from them, it will evidently be impossible for him to force his facts to agree with all of them, however much the facts may be trimmed or stretched.

Irregular Order of Procedure.—In practise the several processes that have been necessarily considered in systematic succession, are carried on in a much more irregular fashion. It has already been pointed out that invention may advisedly go hand in hand with observation. It is evident that, after a hypothesis has been invented, any time spared from observation may be devoted to deduction; and it often happens that the consequences of the hypothesis may grow to a greater number than that of the classes of observed facts then accumulated. Confrontation and comparison may be made repeatedly as observation advances, and revision is always in order the moment there seems to be occasion for it. The active-minded investigator, thus continually reviewing the different aspects of his problem, may gradually come to feel that one hypothesis, modified as far as needs be from its original form, appears to deserve greater acceptance than any of its rivals; then arises the great question: Is this hypothesis really true? Is it surely a correct counterpart of the invisible facts of the past? Clearly it is essential that an investigator, on reaching this stage in his work, should fully understand the nature of scientific proof.

Final Judgment.—It is at this advanced stage of an investigation that the exercise of a sound judgment is needed, in order to estimate the measure of confidence that may be given to an apparently successful hypothesis. The most important point to emphasize now is that, in such problems as we are here dealing with, the only available method of testing the truth of any hypothesis is to measure the agreement of its deduced consequences with the appropriate facts of observation. In this respect scientific proof is altogether unlike geometrical proof, in which the correctness of a theorem is never tested by its agreement with observable facts, but only by the continuity with which successively de-

duced steps lead forward from the postulated premises to the announced end. Geometry therefore corresponds—so far as a correspondence can be traced between a mathematical and an observational science—chiefly to that part of geological or geographical investigation which is concerned with invention and deduction; for these processes, like the similar processes in geometry, can be performed by mental reflection in the dark, and have no close dependence on observation.

In observational sciences it is necessary to examine critically the different degrees of agreement that may exist between the deduced consequences of an hypothesis and the facts gathered by observation, in order to pass a safe judgment on the value of the hypothesis from which the consequences were deduced. This return to the facts is one of the most important as well as one of the most characteristic elements of scientific work.

If observation has discovered but few classes of simple facts, and if invention has brought forth only one hypothesis, which leads only to a few simple consequences, the value of the hypothesis must remain in doubt, even if its consequences agree rather closely with the facts; because agreement in such a case may be a matter of chance. Here no decided opinion as to the value of the hypothesis should be expressed; judgment must be suspended, and the mind held open for further light, either from observation, invention or deduction. Again, if, as above pointed out, the groups of consequences deduced from two or more rival hypotheses are about equally successful in matching the facts, no judgment must be pronounced in favor of either, however strong the investigator's desire to reach a conclusion may be. But if the peculiar and numerous consequences of a certain hypothesis agree to a remarkable extent with the highly specialized groups of abundant and varied facts, such an hypothesis is strongly commended thereby, for the possibility of accidental agreement is greatly diminished as the facts and consequences to be matched become more complicated, and as the number of agreements increases. Furthermore, if the facts, as at first collected, seem of arbitrary occurrence and unrelated distribution, and yet are afterwards found, by the suggestive aid of an hypothesis and its deduced consequences, really to possess a previously unsuspected order and many previously unseen relationships, the hypothesis which leads to this larger and clearer view is thereby greatly recommended; for it is highly commendable to a theory, if it leads to the discovery of reasonable system where confusion seemed to prevail.

But we must go further; for it often happens that, after an hypothesis has been invented, and after its consequences have been successfully confronted with the previously observed facts, new classes of facts may be discovered for which deduction had provided no appropriate

consequences. If an impartial revision of deduction then leads to the detection of new consequences which agree with the new facts, such added agreement greatly increases the probability of correctness adjudged on the previous agreement. More significant still is it, when certain peculiar or complicated consequences are deduced, for which no corresponding facts had been previously discovered, and when a return to the field of observation discovers facts of the peculiar character and in the significant situation assigned to them by deduction. This gives wonderful strength to the hypothesis from which consequences so prophetic can be derived: indeed, evidence of this is usually regarded as convincing, for the possibility of such a degree of accordance of consequence and fact being the work of chance is practically ruled out. Finally, if in the course of years, many investigators find many complicated facts in many parts of the world, all of which are successfully matched by the elaborate consequences of an hypothesis that was invented long before observation was so widely extended, the probability of correctness rises to so high an order that the truth of the hypothesis may be accepted, and it may be promoted to the rank of an established theory. The unseen facts that such a theory reveals are commonly accepted as of an equal degree of verity with the facts of direct observation.

The will or the wish of the sane investigator has no power to withhold belief, when this stage of theorizing is reached. And yet it can not be too carefully borne in mind that even if all the above requirements are satisfied, the most that can be said for the established theory is that its probability of correctness is so high that its chance of error may be disregarded. The fair-minded Playfair phrased this aspect of our problem admirably a hundred years ago in the case of river valleys:

> Every river appears to consist of a main trunk, fed from a variety of branches, each running in a valley proportioned to its size, and all of them together forming a system of vallies, communicating with one another, and having such a nice adjustment of their declivities, that none of them join the principal valley either on too high or too low a level; a circumstance which would be infinitely improbable if each of these vallies were not the work of the stream that flows in it.[3]

It is particularly in this matter of the increasing probability of correctness that the nature of geological or geographical proof is so unlike that of geometrical proof. There is never any talk of increasing the probable correctness of a geometrical theorem, when several different demonstrations are given for it. Each demonstration is absolutely correct alone, as far as anything can be absolute in the limited experience of our finite minds. But in our subject, it is always appropriate

[3] J. Playfair, "Illustrations of the Huttonian Theory of the Earth," Edinburgh, 1802, 102.

to speak of the increasing probability of correctness of a conclusion, even though general acceptance was given to it before.[4]

It is, furthermore, important to recognize that a fundamental but unprovable postulate underlies all this discussion; namely, that the present order of nature is persistent; that is, that time is continuous, and that physical forces have always conformed to the laws which now prevail. For however ingenious or amusing may be the speculations of the metaphysician as to another order of things—for example, as to a past condition of existence in which gravitation worked irregularly and variably, or as to a period of time when energy was created and matter was destroyed in haphazard order, or when time itself began or stopped—the scientist is not concerned with them, because they utterly transcend experience. All his discussions and conclusions as to the events of past time and the origin of the present features of the earth are of no avail, if his essential postulate of the persistence of the present order of nature is erroneous; but the frank recognition of this fundamental principle need disturb no earnest observer of the face of nature. Whatever doubts regarding the conclusions of science may be expressed by the ingenious metaphysician, with his fancied possibilities as to such inconceivable conditions as the beginning of time or the creation of matter; and whatever dissatisfaction may be expressed, regarding conclusions that are based merely on an unproved postulate and measured only in terms of high probability, by the absolutist who wishes to reach unconditional demonstration in all things, the scientist need not be disconcerted. He must still base all his work on the long accumulated and carefully tested results of thoughtful experience, for his work can have no other base; and he must accept as satisfying, even if not as absolutely certain in the absolutist sense, those high degrees of probability that are attained by well established theories, for there is no other satisfaction he can reach.

[4] "Bearing of Physiography on Uniformitarianism," *Bull. Geol. Soc. Amer.*, VII., 1896, 8–11.

PROFESSOR BROOKS'S PHILOSOPHY

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WHEN one examines the development of thought from the time of the early Greeks to the present, one finds that science and philosophy have in general ever kept pace in development and that their relation to each other has always been one of mutual and reciprocal suggestiveness. At certain times, of course, it has been the one, at other times, the other that has been dominant in its influence; but at the beginning, granting this to have occurred among the Greeks, neither was first, for both arose and for a considerable period developed together as an organic whole. The subsequent differentiation of problem and of method, although it can not be denied to have had its incipience in ancient thought, was in almost total abeyance up to the time of the Renascence, and is, of course, one of the distinguishing characteristics of modern thought. As a result of, or as identical with, this differentiation, we have to-day not only the great diversity of special sciences, but, as included in these, we have also bodies of systematic knowledge or "doctrines" which to many seem far removed from the practical and the factual. As good examples of such there may be cited the Hegelian philosophy, non-Euclidean geometry, the theory of assemblages, etc. However, not only do such bodies of knowledge or "doctrines" seem to be far removed from an empirical basis, but, more than this, they are often cited as standing in thorough-going opposition to the empirical sciences, and accordingly are frequently treated as pure speculations. To what extent this stigma is a merited one, I will not here discuss, but I shall be content to assert merely that an examination of their development shows clearly that these "doctrines," or whatever they may be called, have grown out of an earlier period of thought in which their progenitors were "near relatives" to the members of the distinctly empirical group. Accordingly, the influence of empiricism is not really lacking in them, but, rather, they are the products of the process of making explicit that which is at least held to be implied or involved in certain systems, philosophical and scientific, which are in direct contact with empirical problems and methods. Thus, as illustrating this and as forming a well-known and generally accepted instance of philosophical development, it may be said that Hegel goes back to Kant, Kant to Hume (in part), Hume to Berkeley, and Berkeley to Locke; and Locke worked out his philosophy, which concerned

primarily the question of the "origin, extent and validity of knowledge," in thorough-going dependence on the mechanistic views and science of his time.

Although philosophy may at times, then, seem to get far away from contact with the empirical and the practical, still this may well be only a "seeming," and there may be and generally is a very genuine continuity of influence and of knowledge through the threads of that consistent and rigorous reasoning which forms the discovery of implications and presuppositions. But even a remoteness of this kind is not always the case. Far more frequently, indeed, has there been intimate contact and close relationship, if not within the mind of one man, then as within that larger whole which we call the *Zeitgeist,* whatever interpretation may be given to this.

As concerns scientists and philosophers, it must be admitted that all of them are educated and develop with that whole body of knowledge which the human race has won theoretically accessible to them. But specialized environment and congenital predisposition really limit this accessibility considerably, and together result in specialized interests and specific development. But this means only that from a great body of knowledge certain parts are selected and become revivified in the mind of some individual, to furnish the basis for further development, for originality, for discovery, for advance. Yet as this process occurs, it issues in a two-fold result. There is a certain unity in knowledge, not of that kind which means that any part is theoretically or *a priori* deducible from any other part, but in the sense that there are many parts or aspects of reality to be known, and that knowledge of them must form a logically consistent whole. Now education and training may result in a mind which is aware of all this, in a mind, therefore, which, although it is fully informed, and critical, and constructive in some special field, is also fully aware that this field is but a part of a larger whole and that through this relation special investigation gets its significance and importance. Such a mind may be said to be philosophic, or, if one prefers, scientific in the best sense of the term. On the other hand, intellectual development may result in a mind which is seemingly unaware, even ignorant of the history of the race, of its thought, of its hopes and aspirations, a mind which accordingly finds the *summum bonum* only in one line of thought and investigation, which ignores or even denies the relation of this to a larger whole, because it is ignorant of this whole, and which accordingly pursues its own way along the straight and narrow path of only highly specialized investigation. While one must not speak disparagingly of such minds, since the history of thought shows quite clearly that to these also are due very important contributions to knowledge, still of such a mind it must be admitted that it has the defects of its qualities, namely, that it

is in danger of wasting its strength on that which is not significant, and that in studying, for example, the problem of life it frequently forgets both what life itself is as well as how to live.

It is very distinctly to the former type of mind that Professor Brooks belonged; for, keen-sighted pioneer and influential biologist that he was, he was also in thorough sympathy with life and the living in all of their aspects, past, present and future, emotional, intellectual and religious. Perhaps for that reason, too, he was the great teacher and the inspirer of men that with one acclaim he is acknowledged to have been. Technical philosopher he was not, sophisticated philosopher he was not, but sympathetic philosopher he was, and in this respect, since he was biologist also, he was unusual. Contributions to philosophy, also, he did not make, but rather, conversely, he let philosophy make contributions to him, and in this he was again unusual. And yet all the time he was on the lookout in the various fields and aspects of biological science for that which was of genuine significance, for that which had a bearing on some of those great questions whose solution is of paramount interest and importance and which, therefore, are eternal questions.

These statements concerning Professor Brooks will be made more convincing by considering some of the typical instances in which he brings philosophy and science together. In fact, it is only such *instances* that can be cited; for of system, either in philosophy or biology, Professor Brooks was quite innocent. Significant and typical of the general attitude which he took, and forming indeed a discussion of one of the most salient problems in biology, physics and philosophy, are the data, the arguments, etc., advanced in Lecture II., entitled "Huxley and the Problem of the Naturalist," in The Foundations of Zoology. Here Professor Brooks cites in particular Huxley's statement: "If the properties of water may be properly said to result from the nature and disposition of its component molecules, I can find no intelligible ground for refusing to say that the properties of protoplasm result from the nature and disposition of its molecules," and follows this with comments which amount to his taking this position: Huxley's statement can be granted to be valid, but, so granting it, it does not mean that there is or ever can be the possibility of an *a priori* deduction of the properties of protoplasm from those of its constituents, but that the connection between these must be bridged by induction. For the properties of protoplasm, or indeed those of the organism at any level are not the additive result of those of the parts, but contain something quite new. Thus Professor Brooks indicates the limitations of the mechanistic view of life, limitations which, however, are found as well in the inorganic realm, and which, therefore, demand that in applying theoretical mechanics to nature, either inorganic or organic,

an appeal must always be made to experimentally obtained fact in order to discover those constants which are actually found and used in the equations of applied mechanics (*vide* the gravitational constant). It is the failure to make this distinction between theoretical and applied mechanics, with a resulting misinterpretation on both sides, that has conditioned psychologically the tenets of those two schools, namely, the vitalistic and the mechanistic, between which there has been so much discussion of recent years. In his attitude toward mechanism the adherent of each school has in mind a different thing, with the consequence that there is no genuine joining of issue so far as the fundamental problem is concerned, while there may be and, I think, really is a genuine agreement in regard to it. Thus, in opposing the view that the organism is a mechanism, the vitalist tacitly means that it is not a mechanism in the sense of pure, theoretical mechanics, *i. e.*, of the "geometry of motion," as a deductive system; and in this he is right. But he really also always admits, at least tacitly, that the organism *is* a mechanism in the second sense, *i. e.*, that, although it has properties which can not be deduced from those of its parts, the former nevertheless result from or are determined by the latter.[1] On the other hand, the mechanist, in opposing vitalism, first fails to make clear that his own position is that the organism is a mechanism in the second sense, and, secondly, wrongly considers the vitalist to be opposing this second view, whereas he is really opposing only the first, the purely theoretical, deductive, mechanistic position.

This solution of the problem is, in fact, recognized by Professor Brooks, and the development of its consequences forms the chief part of his philosophical position, as will be seen subsequently, but it is a solution which, as demanding that the actual properties of nature at any level of synthesis must be found by observation and experiment, both allows that the organic realm has certain properties which the inorganic world has not, and yet that these should be interpreted and treated mechanistically in the second sense. Most intimately connected with this whole question are a number of other philosophical considerations to which Professor Brooks gives much attention. It is from these that he arrives at that which is really his ultimate philosophical position, although, it must be admitted, this is not a very complex or sophisticated one. For Professor Brooks, although he cites and quotes from such sophisticated thinkers as, *e. g.*, Plato, Berkeley and Kant, is predominantly (he is not always consistent) a realist, first "naïve," and then "critical." Thus, although he dedicates his "Foundations" to Berkeley, and quotes him oftener than any other philosopher, he never seems quite to grasp this philosopher's subjective idealism. And

[1] Cf. Driesch in various places in such volumes as "Naturbegriffe und Natururteile" and "The Science and Philosophy of the Organism."

as with Berkeley, so with the others; for example, he never quite gets hold of Kant's phenomenalism. It is Hume, however, who, through that analysis of causation which made him famous and which constitutes the basis for the logic of induction, is of dominant influence on Professor Brooks. The results which Hume obtained are, as is generally well known: (1) that, tracing our concept of cause back to its origin in perception, there is given here only sequential and factual but never necessary connection; (2) that, however, from the experience of frequently repeated specific sequences, a belief in their regular and uniform and even necessary occurrence is generated, or, more generally, that a belief in a universal, necessary order is formed. (3) The belief is justified and is of value *practically,* but nevertheless, that there is a universal and necessary regularity or order is a pure assumption, or (Mill) it is itself that generalization, by induction from a limited number of cases, which lies at the basis of all specific inductions and gives the "inductive syllogism." All this means that, although a purely deductive theoretical mechanics as = "the geometry of motion" is possible and as such may be identified with determinism, this can be applied to nature only by finding the numerical values for certain functions or properties or qualities *experimentally and factually.* It means, accordingly, that in just this respect nature is not deductive, is not determined, and that the view that it is "order" is an assumption neither proved nor provable. This does not mean that the same cause under the same conditions does not bring about the same effect; it may, or it may not, but that this *is* the case is simply the same assumption over again.

It is on the basis of this criticism and analysis of causation, of "order," etc., that Professor Brooks discusses very interestingly such topics as the "Philosophy of Evolution," "Paley and the Argument from Contrivance," "The Mechanism of Nature," etc. If mechanism is to be equated with determinism and "order"—and that is all that it really means to the majority of biologists as well as to the majority of people—then it also is, like them, as above explained, only a pure assumption. But the possibilities or consequences resulting from this are interesting and important. For, with it unproved that there is that kind of continuity and causation and "order" and determinism which would make a purely deductive knowledge possible, there is the logically valid opportunity for spontaneity and genuine discontinuous origin and freedom and teleology and purpose; and yet all of these are quite consistent with that other view of "order," etc., which means that, when specific instances of these have once been discovered by induction, the presumption and the probability is that under the same conditions they will recur. But this simply means that there is a genuine evolution and advance which is at once compatible with mechanism in the above

second sense of the term and which yet, as made up of the appearance of new existents, is itself irreducible to continuity, and is uneliminable.

But it is in substance just this view which Professor Brooks accepts and defends in one way or another in a number of Lectures of the Foundations. In order to carry confirmation to the reader's mind that this is the case a few typical passages may be quoted. Thus we find Professor Brooks saying: "So far as I can see, the reduction of all nature to mechanical principles would mean nothing more than that all phenomena of nature are orderly."[2] "When we say nature is orderly, we mean each event may be a sign which leads us to expect other events with confidence."[3] "When, as commonly happens, we change *will* into *must,* we introduce an idea of necessity which most assuredly does not lie in the observed facts."[4] Of peculiar interest, since, in perfect agreement with Professor Brooks's general view as above expounded, it reveals his position as to the relation of mind and matter, is the statement that "if such a discovery (*i. e.,* that these two worlds are different aspects of one and the same world reduced to mechanical principles) should ever be made . . . I can not see how it could possibly show that mind is anything but mind."[5] Briefly, this means that if consciousness were found to be, for example, energy, it would be that kind of energy which would have just those properties which consciousness is found empirically to have. Professor Brooks would then bring mind itself within nature, *i. e.,* he would treat it, like other things, quite empirically, and this, I think, is the correct position. But it is a position which has interesting consequences! For, on the one hand, let his interpretation of causation and "order," etc., be remembered. Now Professor Brooks holds that this same interpretation applies also to mental events; the "order," causation, etc., here are factual only to the limited extent actually observed; beyond that they are assumptions. But what is it that makes the assumptions? Why the mind itself, which either is, by the *same interpretation,* simply the series of mental events, *or,* if not this, is something more. In the former case we have, then, that which is assumed "order," namely, mind, assuming "order" elsewhere, and so on again and again. Consistency demands, then, that it be admitted that that which may be indeterminate, namely, nature, is known by that which is also indeterminate, namely, mind! But the consistency is itself an element in this latter indeterminateness. The situation thus resulting is, of course, a perplexing one; for, to look at it from a slightly different angle, it means that Professor Brooks as evolutionist makes mind and life, with their assumed "order," etc.,

[2] Foundations, p. 289.
[3] *Ibid.,* p. 305.
[4] *Ibid.,* p. 294.
[5] *Ibid.,* p. 308.

develop in response to the "order" of nature;[6] but this response is itself only another term for causation, and must, in order to ensure consistency, itself be interpreted like other cases of causation. But this means that everything is brought within a causal "order" which is held to be only assumed but not proved or provable. And yet it would seem that the very attempt to *ground* this general view presupposes the contradictory position, namely, that there is a causation, a necessary connection, a unique determination and "order," which are more than assumed. That there is this causation is, however, a view quite compatible with the discontinuity view previously advanced.

Professor Brooks is seemingly not aware of this last possible supplementation of his view, but yet he says nothing which would contradict it. By it the causal connection, discontinuous though it be at certain points, the "order," etc., *are more* than assumed; although assumptions may be made about them, *they* are factual.

In accordance, now, with this whole general position, Professor Brooks (rightly) finds freedom quite possible logically because, as a fact, it is quite compatible with "order," and does not mean disorder, nor yet ultimate necessity. "We know we are free to do as we like; and we also know there are reasons why we like to do as we do." Briefly "The reduction of all the phenomena of life to mechanical principles would show that our likings and dislikings are what they might have been expected to be," and "would not disprove the reality or the value of any one thing we discover in our nature."[7]

Quite in line with all this is also the "immanent teleology" which Professor Brooks accepts and which may be made clear by a quotation both apt and amusing: "He who admits that cats are part of nature, and that skill in catching mice is important to the race of cats, must admit that nature is, so far, useful to itself."[8] Thus the teleology falls within the "order" of nature, is quite compatible with it, and indeed applies to a special group of phenomena within this (assumed) causal order. Either description may be made and both are correct.

Concerning the other philosophical aspects of Professor Brooks's writings much need not and indeed can not be said. To be sure, all through the Foundations he is continually quoting from some philosopher, or is raising some philosophical problem, but further than this he does not go. He does not contribute very much at least to the solution of these problems, but, rather, chooses certain statements and points of view of the philosophers as contributing to his own views. But he thus at all times reveals the heartiest sympathy for the results of the philosopher's reflections. "Whether it is desirable to place a prohibi-

[6] For example, in the chapter on "The Mechanism of Nature."

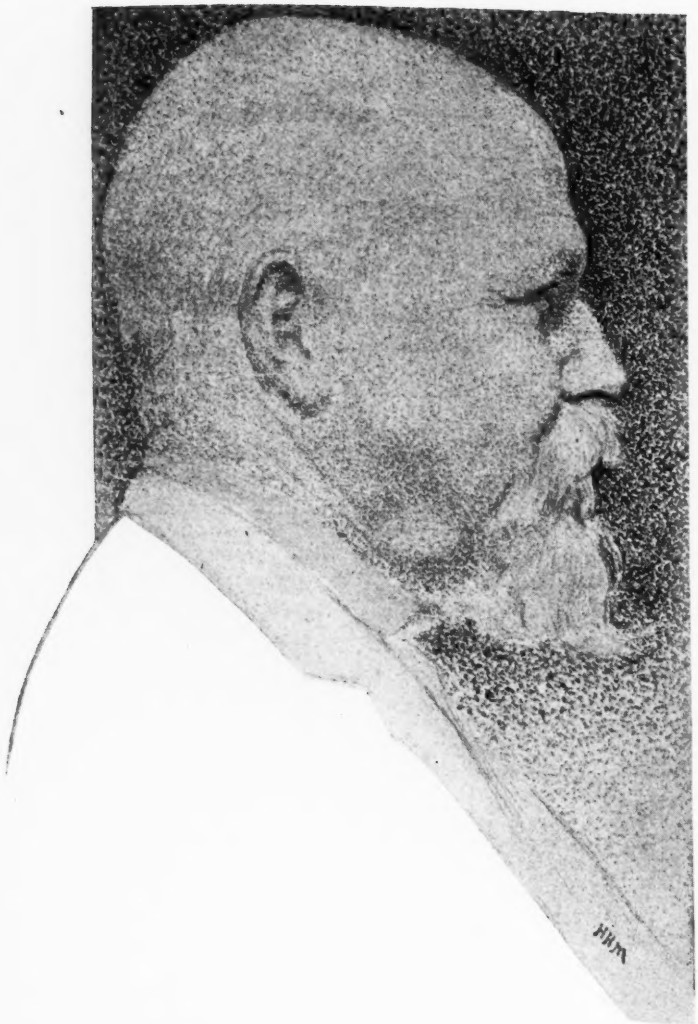
[7] Foundations, pp. 310–12.

[8] *Ibid.*, p. 305.

tory duty upon philosophical speculations or not, it is utterly impossible to prevent the importation of them into the mind," he says, and further raises the question if it is "not a little curious to observe that those who most loudly profess to abstain from such commodities are, all the while, unconscious consumers, on a great scale, of one or another of their disguises or adulterations?"[9] In this spirit he recognizes that such philosophical problems as those of "knowledge" and "consciousness," of the "principles of science" in general, of cosmology, and, more specifically, of psychology and ethics, are problems which must be solved in order to make the scheme of knowledge complete. What he does not recognize clearly, or at least does not develop, is the fact that, whereas the greater part of biology is consistent with any one of a number of philosophical systems, it is through evolution that a particularly strong leverage is secured by which it can be shown, perhaps, that only one point of view, namely, evolutionary realism, is the correct position; but just how this is the case I can not here demonstrate.

Some of the specific problems above mentioned are indeed discussed by Professor Brooks in some detail, but not very satisfactorily. A few lectures are almost purely biological, with only now and then a philosophical reference, but in general it may be said that, even including these, Professor Brooks is philosophizing all through the Foundations as well as in his other writings, and that in this characteristic rests his unusualness as a biologist. For while, of course, it must be admitted as a well-known fact that his philosophical interest did not lead him to give up the exact observational investigation of detailed problems, one must go further, I think, and say that it was this same interest also that actuated and stimulated him in all such investigations by placing him ever on the lookout for the significant and important task. But yet at the same time he did not ally himself with any specific and definite constructive metaphysical system, not even with that of Berkeley. In fact, it may be said that with the real inner meaning of the majority of the great historical systems Professor Brooks seems to have been unacquainted. It is, rather, by virtue of his openness of mind, of his search for significant problems, and of his motivation by the spirit of philosophical investigation and criticism, that he not only allies himself with philosophy, but was himself a philosopher, and in all this he furnishes an example most worthy of imitation, if not of emulation, by the investigator in any special field of scientific research.

[9] Foundations, p. 25.



Alpheus Hyatt

ALPHEUS HYATT, 1838–1902

By Dr. ALFRED GOLDSBOROUGH MAYER

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ALPHEUS HYATT, junior, was born in Washington, D. C., on April 5, 1838.

Late in the seventeenth century, the ancestors of Alpheus Hyatt moved northward from Virginia into the young colony of Maryland, where they soon became large landed proprietors and raisers of tobacco; the colonial manor of Tewkesbury on the Potomac River being owned by Charles Hyatt, Esqr., the great-grandfather of Alpheus Hyatt, senior. Hyattsville was also the seat of certain of Alpheus Hyatt's ancestors.

Alpheus Hyatt's father was a leading merchant of Baltimore, and in common with many men of affairs in southern cities, he made his home in the country; each day driving in to his counting-house in the city. The old Hyatt home was "Wansbeck," a colonial mansion shaded by great oak trees and placed upon the summit of a hill far from the city's dust and turmoil. It still stands to-day, but is now in the heart of the city at the corner of Franklin and Schroeder Streets, where it serves as the Child's Nursery and Hospital of Baltimore.

Here among the woods and fields of "Wansbeck" young Hyatt began his studies in natural history, becoming an ardent collector of insects and aquatic life; a pursuit which brought him into intimate comradeship with young Alfred Marshall Mayer, a boy of nearly his own age. The friendship between the little naturalists lasted through life, although Hyatt, true to his early inclination, remained constantly a student of animal life, while Mayer eventually became a physicist. Hyatt's interest in paleontology was first awakened by the sight of a collection of minerals and fossils possessed by one of his early teachers, Captain Allen, a retired army officer.

Although none of Hyatt's ancestors had been distinguished for remarkable mental characteristics, and none had sought intellectual or even professional careers, his mother was a woman of strong and decided character and an amateur artist of considerable ability, some of her copies of old masters and tapestries being noteworthy. The abundant means possessed by his father afforded him every educational advantage of the day, and his early education was commenced under private tutors, but soon he was sent to the Military Academy of Oxford, Maryland, to be prepared for Yale University, which he entered as a freshman in 1856.

"WANSBECK" AS IT IS TO-DAY.

It may be of interest to observe that upon his arrival in New Haven his father presented his name to various tradesmen of the city, directing them to supply his son's demands upon them, and as these included the opportunity to order all that livery stables or wine cellars could provide, it is greatly to young Hyatt's credit that he was a sober, serious-minded, hard-working student from the moment of his arrival in New Haven.

He remained only one year at Yale, and then his mother withdrew him from college and took him to Italy, where he came under the influence of certain catholic friends of the family who sought to convert him to the service of the church. In his journal he gives a graphic description of the magnificence of the papal court, but is distressed that "the Swiss guards in their harlequin uniforms stand fencing off the high altar from the approach of common people." He might still have acceded to the counsels of his mother's catholic friends had he not one day seen the pope's dragoons charge wantonly and without warning upon a crowd of merrymakers on the Corso, crushing four of them to death. The horror of this scene, and the filth and misgovernment of Rome under Pius IX., turned him with loathing from all thought of serving such a heartless régime as that of the papacy of those days, and in his journal he exclaims:

> How much do I love my own country after witnessing that disgraceful scene on the Corso. How I prize her free, glorious institutions where a man's life, will and speech are his own and not the property of emperor, king, or potentate. God bless my native land and preserve her as a living light to these poor down-trodden, though fine people.

He was but nineteen years of age, yet he had now determined to devote his life to science.

In 1858 he returned to America and entered the Lawrence Scientific School of Harvard University, studying engineering, but the great Louis Agassiz, always seeking promising young pupils to instruct, soon discovered Hyatt and drew him into his own laboratory of natural history, where in an inspiring atmosphere of research and study he was to form close and life-long friendships with his fellow students Clarke, Morse, Packard, Putnam, Scudder, Shaler, and Verrill. With them in 1860 he formed the Agassiz Society which met at frequent intervals to discuss zoological questions, Professor Agassiz himself attending the meetings, and in the summer of 1861 with Shaler and Verrill as companions he went to Anticosti Island in the Gulf or St. Lawrence, collecting fossils and marine animals.

Louis Agassiz's lucid exposition of von Baer's law and his own additions thereto, and his high praise of the philosophy of Oken, produced a profound effect upon young Hyatt's mind, and he is said to have learned Agassiz's "Essay on Classification" by heart. One of the most graphic of Louis Agassiz's lectures was upon the coiling and final uncoiling of the shells of fossil ammonoids in which he compared the twisted forms found in the Cretaceous just before the extinction of the group, to the writhing contortions of a death struggle. Listening to this lecture, Hyatt became so inspired that he determined then and there to devote

PROFESSOR HYATT'S DESK, as it was when he left it on the day of his death.

his life to the study of these fossils. It can not be said, however, that he was entirely moulded by Agassiz, for Hyatt was a fearless and independent thinker, and though modest in the expounding of his views, he nevertheless clung tenaciously to his own opinions.

Few men of science have been so free from egotism as was he. He was a kind friend to many a young student of Harvard, for he never seemed to lose his contact with youthful thought, and delighted to receive instruction from old and young and every one great or small around him. In his address before the Agassiz Association in Mechanics Hall in Boston he tells of this, and unwittingly gives us a charming picture of his own generous mind and kindly heart. He was speaking of things the association might do to disseminate an understanding of natural history, and told of his friendship with an old farmer who had formed some geological theories of his own and who knew Professor Hyatt simply as "the man as studies rocks." Hyatt says:

> The wonder and delight in his old, wrinkled, weather-beaten face on finding that his ideas were not merely local, but universally true, and what he had thought out was not ridiculed but regarded with respect was a sight I have never forgotten.

He concluded this address by saying:

> The minerals, the rocks, the plants, the animals, the earth, the planets and the stars are full of facts unknown as yet to us. These are nature's books, the volumes are everywhere and no one is so poor that he can not have access to them—these are the books of the future, and eventually we shall have them collected in museums and issued as printed volumes now are for the instruction of the people.

In 1862 Hyatt graduated from Harvard with the degree of B.S., his scholarly standing being higher than that of any of Agassiz's pupils who had until then obtained this degree.

His inclinations were all for science, but the civil war had broken out and he felt it his duty to serve in the Union Army. His mother he succeeded in persuading into an acceptance of his views, but it was far otherwise with the remaining members of his family, from whom he became estranged only to be reunited after years of silence. He aided in raising a militia company in Cambridge and enlisted as a private, but was almost immediately commissioned a lieutenant and afterwards promoted to be a captain of the 47th Massachusetts regiment. For a time he was stationed upon Cape Cod and afterwards ordered to New Orleans, where he served as aide-de-camp on General Emory's staff.

I have a letter of this period written by the late Professor N. S. Shaler to their mutual friend, George H. Emerson, in which he says:

> So Hyatt has gone into the smoke of the great battle. May God defend him and grant him immunity from the fate of so many of our brave. He will win success and will make at once a good follower and an equally good leader.

The war being over, he was honorably discharged, and returned to Cambridge in 1865 to continue his studies. Louis Agassiz at once

placed him in charge of the fossil cephalopods and this collection remained under his care until his death in 1902.

In 1865 he published his first scientific paper, a short one of only five pages in which he states that the Beatricidæ which he collected at Anticosti in 1861 are not fossil plants as others had supposed, but cephalopods. We know, however, that he was himself mistaken, for they are now believed to be hydrocorallines.

In the same year he wrote an appreciative notice of the life of his young college chum, George H. Emerson, a chemist of great promise, whose untimely death from overwork had terminated at its very beginning a useful life in science. While in college together Emerson and Hyatt had begun the critical study of the bible, Hyatt coming to entertain liberal views while Emerson became a ritualist. It was characteristic of Hyatt to disagree upon essential matters with his closest friends and yet never in any sense to lessen the mutual esteem and affection between him and them. His simple honesty, freedom from conceit and above all his cordial and generous nature made this possible. Thus it was that within a year of the time when he began his studies under Agassiz he became an evolutionist and an admirer of Lamarck, whom Agassiz characterized as "an absurd egotist." Independent of the theoretical side of his work Hyatt will be remembered as a great teacher and a leader in systematic zoology, for he was an uncommonly accurate observer and his publications present a vast body of well-founded facts.

The year 1865 saw Louis Agassiz's pupils, whom the war had scattered, again working by their master's side at Harvard. But the old relation of master and pupil could not long endure, for the truth was that the time had come for the young birds to fly from the paternal nest, and in 1867 Morse, Packard, Putnam and Hyatt severed their relations with Agassiz and cast in their lot with the Essex Institute of Salem; this movement being known as the "Salem secession." Salem thus became an active center in the natural sciences and so much public interest was awakened that in 1869 these four young men cooperated with a number of progressive citizens of the town to found the Peabody Academy of Sciences, and with the aid of Scudder and others they succeeded in establishing the first permanent American journal devoted to the natural sciences, *The American Naturalist,* Hyatt being one of its editors from 1868 to 1871.

On January 7, 1867, he married Miss Audella Beebe, daughter of Smith M. Beebe, Esq., of Kinderhook, N. Y.

During the period of his residence in Salem, Hyatt continued to study and to describe the fossil cephalopods of the Museum of Comparative Zoology at Harvard. Suess and Hyatt were indeed the first zoologists to attempt to distinguish genera and species among the ammonites, and Hyatt was the first to announce the fact that these

fossils constitute a great group of the animal kingdom probably equivalent to a suborder. In 1867 he named 26 genera and 126 species of ammonites.

He also made a detailed and very careful study of the anatomy of the so-called "moss-animals," or fresh-water Polyzoa, the structural details of the species being tabulated in order to facilitate comparisons. This work was published in the *Proceedings of the Essex Institute,* in 1866–67, and also in the *American Naturalist,* and is illustrated by careful and accurate outline figures drawn from life by Hyatt and beautifully engraved on wood by that matchless draughtsman E. S. Morse. In this and all of his subsequent papers Hyatt furnishes a model that systematic zoologists will do well to follow in the accurate and detailed description of species.

While at Salem he also began that study of sponges which was to make him the leading authority among systematic zoologists of America upon these animals. His principal papers upon sponges were not published, however, until 1875–78 in the *Proceedings* and *Memoirs of Boston Society of Natural History.* He agrees with MacAllister that sponges constitute a subkingdom or branch of the animal kingdom equivalent to one of the larger divisions. He describes 36 new species, and gives an excellent account of the methods of the commercial sponge fisheries of Florida, and discourses upon the embryology, anatomy, physiology and relationships of sponges, deciding, in common with Barrois, that in sponges there is no gastrula stage.

But Salem was too small to provide careers for so many young, active and well-trained students of natural history. Of the four friends, Morse remained in Salem; Packard went to Brown University; Putnam became an anthropologist and curator of the Peabody Museum in Cambridge and also in other institutions; and on May 4, 1870, Hyatt was elected custodian of the Boston Society of Natural History. In 1881 he became its curator and remained the scientific head of the society until his death in 1902.

After 1873 he made his home in Cambridge, where he could be near the great collection of cephalopods of the Museum of Comparative Zoology, and in 1879, under the auspices of the Woman's Educational Association of Boston, he established a summer laboratory for the study of marine zoology upon his country place at Annisquam, Mass. At this time also he owned a 60-foot schooner yacht, the *Arethusa,* with which he made scientific cruises along the New England coast, going as far north during the summer of 1885 as the west coast of Newfoundland and lower Labrador, to study the fossils and the general geology of these regions. His companions upon this cruise were five young men, among whom were Professor George Barton and the late Dr. E. A. Gardiner.

The situation of Annisquam was found to be unfavorable for the site

of a general marine laboratory, nor was Hyatt sufficiently interested in the minutiæ of executive detail to make a good director of a permanent station, so after a few years the Annisquam project was abandoned and the laboratory was removed to Woods Hole, Hyatt being the first president of its board of trustees.

Hyatt was a great, generous-minded, altruistic man; who formed warm and enduring friendships with those about him. He was a teacher and a student rather than an executive, and his faith in young men was one of the beautiful sides of his character. Advocates of peculiar theories of their own making are commonly conceited or narrow-minded men, but Hyatt was the reverse of this, for his modesty was real, and his breadth of view, founded as it was in superior knowledge of science, and in interest and respect for those about him, was constantly expanding. No man could have been more approachable, and no educator of his generation was more highly esteemed for his kindly personal qualities than was Alpheus Hyatt.

His interests in educational affairs in Boston caused him to be appointed professor of zoology and paleontology in the Massachusetts Institute of Technology, a chair which he held for eighteen years. He was also professor of biology and zoology in the Boston University from 1877 until his death in 1902.

But it is as a teacher of teachers that he will be best remembered by the public of Boston. He loved to teach, but was never a pedant, for as he says:

> Teacher and scholars should recognize that science is infinite, and they should work as companions learning from each other's observations. Better a child should learn to handle one animal, to see and know its structure and how it lives and moves, than to go through the whole animal kingdom with the best teacher.

His knowledge of invertebrate zoology was profound and extensive, and he had an apt manner in illustration which made his lectures popular and brought his pupils close to nature; as Agassiz said of him, "he possessed the essential element with which to engage the attention of an audience—knowledge thoroughly his own." In 1870 with support from Mr. John C. Cummings and the cooperation of many educational leaders and philanthropists, he organized the Teacher's School of Science and gave courses of lectures upon biology to the public school teachers of Boston. Between 1870 and 1902 more than 1,200 school teachers attended these lectures, and the school is still being successfully conducted by Professor George Barton. A good account of the origin and history of this school is given by Frances Zirngiebel in POPULAR SCIENCE MONTHLY, August and September, 1899.

Professor Goodale suggested that guide-books of a peculiar character should be written for the benefit of the teachers who might attend these lecture courses; accordingly, between 1878 and 1896, thirteen short

guide-books designed to meet the requirements of the school were published, the authors being Mrs. Agassiz, Dr. H. P. Bowditch, Professor George L. Goodale, H. L. Clapp, Ellen H. Richards, W. O. Crosby, Hyatt, and Hyatt and Arms. Five of these pamphlets are by Hyatt; their titles are "About Pebbles," "Commercial and other Sponges," "Common Hydroids, Corals and Echinoderms," "The Oyster, Clam and other Common Mollusks," and "Worms and Crustacea"; and in 1890 he published in collaboration with Miss Jennie M. Arms (now Mrs. Sheldon) a remarkably clear, concise and well-worded book upon insects. This is the most elaborate guide-book of its series, and no work could give a clearer idea of the distinctive characters of the sixteen orders of insects classified in accordance with Brauer's scheme from the lowly organized Thysanura to the highly specialized Diptera. As a school-teacher's guide it is unsurpassed, and its clear explanations are admirably supplemented by 223 outline figures of common American insects. It is far more than an anatomical treatise, however, for it presents charmingly worded accounts of the development, physiology, habits and ancestry of the various orders of insects. Yet it is not a theoretical treatise, but aims to present to the teachers well-established and incontrovertible facts. Indeed, the authors take pains to advise teachers to avoid presenting mere theories to immature minds.

This association with the teachers in which Hyatt was so deeply interested won high appreciation from the intelligent public of Boston, a concrete manifestation of which appeared after his death in the founding by general subscription of an endowment known as the Hyatt Memorial Fund, the income from which is used annually to transport school children from the city into the country in order that they may be taught to observe nature in the field.

Altogether Hyatt's best work, apart from his researches, was that among the school-teachers of Boston.

Mrs. Jennie Arms Sheldon, than whom none is better prepared to speak, states that "as a museum curator Hyatt never lost interest in the larger plan or 'scheme' which his comprehensive mind had worked out for the arrangement of the material at his command. His 'natural classification' claimed much of his time and thought, and he sought to find assistants who could carry out the details which, naturally, did not interest a mind like his." His plan was that the museum should be so arranged that the visitor on entering should pass from the simple and more generalized groups to those more specialized. He possessed considerable mechanical skill, and delighted in hours of recreation to work as a carpenter and machinist upon his country place at Annisquam, and his invention, the "Hyatt bracket," has proved useful not only in museums but elsewhere.

At first sight, it must seem strange that so able, inspiring and lov-

able a teacher as Hyatt should have left so few disciples of his school of research, but it must be remembered that he enjoyed no opportunity to teach the young men who were pursuing the higher courses in zoology at Harvard. Through an unfortunate arrangement those who had charge of the various collections in the Museum of Comparative Zoology were not encouraged to give lectures to students, and they worked on throughout the years, their voices silenced, yet with active young minds eager to listen and to learn always near them. Moreover, the spirit of the department of zoology at Harvard during Hyatt's life-time was dominated by Weismannism, and Hyatt's views were thus in disfavor. Upon the rare occasions of his lectures he felt obliged to present not facts—the foundation-stones of his theories—but the theories themselves. Thus the impression grew up that Hyatt was a dreamer and that his theories were based upon erroneous or meager observations. Nothing could have been farther from the truth, for I have myself been surprised, in reading over his publications, to discover that his writings are crowded with accurate observations of indisputable fact, and even if the future should demonstrate that his theoretical deductions are wholly false, he will still be remembered as a great and accurate observer of nature. Concerning the truth or falsity of his so-called acceleration or "old age theory" we are obliged to admit that it has never been disproved even if it be not yet accepted as true. Hyatt's fate may be that of Lamarck and of many another theorizer: Appreciation and respect for his views must come only years after his death.

I will endeavor to give a simple explanation of his theories of evolution, avoiding the complex technical terms which he employed. He believed that the race, like the individual, has only a limited store of vitality and that both must develop, progress, decline and die in obedience to one and the same law. Thus the growth-stages of the individual actually resemble the stages in the evolution of the race to which it belongs; as he puts it, "the cycle of ontogeny is an individual expression and abbreviated recapitulation of the cycle that occurs in the phylogeny of the same stock." "Phylogeny, like ontogeny, is first progressive and thus attains an acme of progress. This acme is followed, however, by a stage of retrogression ending in extinction."

Hyatt derived his ideas of evolution from a study of the fossil nautiloids and ammonoids, those beautiful chambered shells which appear in the Cambrian; and the ammonoid branch of which becomes extinct in the Cretaceous, while to-day the half-dozen species of *Nautilus* are all that remain of the nautiloids. He was an ardent student of these fossils, and of the 103 titles in the list of his papers, 38 are upon these shells. He proved that the ammonoids are descended from the nautiloids, for he discovered that the protoconch or primitive shell of the nautiloids is soft and composed of flexible conchiolin so that it is

usually lost after the chambered shell grows out from it, but in the ammonoids the protoconch is hard and calcareous and is always found at the narrow end of the series of chambers composing the shell.

The undisputed facts are that in Silurian times straight conical shells with smooth outer surface were common, and coiled shells were rare. In the Carboniferous the coiled shells gain in number and nodules, ribs or keels begin to develop upon their outer surfaces. In the Jurassic we find only close-coiled, or uncoiling shells, and those that uncoil tend to become straight with smooth surfaces, as were their ancestors long ago in Silurian times. The ammonoids arose as coiled forms from the nautiloids in Cambrian times, but in the Jurassic and Cretaceous they uncoil and thus resemble their straight-shelled nautiloid ancestors, the oldest of their race. Uhlig, Neumayr, Zittel, Hyatt and all other students of the group agree upon these points, and indeed Hyatt's observations of *fact* have won high respect for both their accuracy and their number. It is only in matters of *inference* that he is at variance with many zoologists.

Hyatt found that in the very young ammonoids the shell is at first straight and smooth, then as growth proceeds it coils upon itself, and may acquire a keeled, ribbed or nodular surface. Finally, if the species be a Jurassic or Cretaceous form it is apt to uncoil in later life, and the uncoiled part of the shell tends to become smooth and relatively straight like its own young stage. D'Orbigny observed these facts even before Hyatt, and they are well authenticated by numerous students of the group. Hyatt, however, pointed out the interesting *fact* that there is a parallelism between the growth-stages of the individual, and the genetic succession of species through which the race has developed. For example, the young shell is smooth and straight as were the adult shells of its primitive nautiloid ancestors of Cambrian times. The adult shell is coiled and ornamented as were those of the ammonites of the Devonian when the race was dominant. The old shell is again straight and smooth as were its Cambrian ancestors and the vanishing remnants of the race that died out in upper Cretaceous times. Thus the growth-phases of the individual—embryonic, larval, adolescent, adult and old age—are correlated with the changes which occur in the geological history of the group to which it belongs.

It may be a mere coincidence, but certainly in ammonites there is a surprisingly close correspondence between the growth-stages of the individual and the phylogeny of its race. Hyatt believes that this fact is not due to accident, but that the life of the individual and the life of the race are related and obey one and the same law.

Zoologists can not understand why this must necessarily be so, but there are many laws in nature which man has discovered, and the logical necessity for which we have not yet understood, and its incomprehensibility has naught to do with the truth or falsity of Hyatt's theory.

One can not, however, establish a general law upon the study of a highly specialized race of animals such as the shell-bearing cephalopods, and we must search through the entire animal kingdom to thoroughly test Hyatt's hypothesis; and zoologists have not yet done this, for the paramount interest in studies of heredity now centers around Mendel's law. Yet Hyatt has raised a burning question—is the course of evolution a predetermined thing, and do the growth-stages of the individual reveal to us the past, present and future of its race? Hyatt says they do, for he states that organisms tend to produce offspring varying in a certain well-defined direction so that we may indicate with tolerable certainty what species a given form can or might produce.

It is sad to think that so few young men have followed him into this great field of study, for a student's life is not wasted even if after years of labor he discovers that his preconceived hypotheses were false and he can not fathom nature's secrets, for it is not for science to advocate, but only to search, hoping to discover.

We will now take up the discussion of Hyatt's law of acceleration or *tachygenesis* as he finally called it; although it was commonly known as the "old age theory." According to Hyatt, modifications, once they appear, tend to develop in successive generations at earlier and earlier stages of growth, so that modifications which first appear in adult life or even in old age before the animal becomes sterile will afterwards be developed in the young stages of descendants. Finally, indeed, they appear in the embryos or are crowded out and replaced by later characters. Hyatt believed this law of acceleration to be an invariable mode of action of heredity.

He also believed in the inheritance of acquired characters, and held that the organism is plastic and irritable and responds to external stimuli by internal reactions which manifest themselves as hereditary modifications of structure. It is interesting to see that the recent researches of Tower and MacDougal have shown that artificially produced changes in the environment may affect the germ-cells and produce hereditary modification of structure.

Hyatt maintained that the evolution of new forms has been more rapid than is generally supposed, and in this he has been supported by the classic work of DeVries, who shows how suddenly a new form may appear and maintain itself. It also accords with Bateson's demonstrations of the frequency of "discontinuous variations." As Farlow says: "Our so-called species are merely snap-shots at the procession of nature as it passes along before us."

Hyatt also states that the development of ancestral forms is usually simple and direct; that of their more specialized descendants becomes gradually indirect with complicated larval or intermediate stages; and that of the terminal retrogressive stages, before extinction becomes again more or less direct. Thus the last is like the first.

He states that most existing types arose in early Paleozoic times when evolution was most rapid. Then came a period of slow changes, especially slow in all races which were in the *acme* or most flourishing period of their phylogeny. Finally, when retrogression sets in the pace of evolution again becomes more rapid, and startling *new* modifications are often introduced.

Hyatt acknowledged that natural selection was a factor which modified the course of evolution, but he believed that the history of a race was a predetermined thing and that natural selection played but a minor rôle in comparison with the effects of the environment. In this latter respect he was a neo-Lamarckian; a view which is now more popular than it was at the time of his death.

He believed that when a number of more or less distantly related or even unrelated forms live in the same environment they acquire a resemblance one to the other; the similarity of external conditions producing a "morphological equivalence" or parallelism.

These are the chief features of Hyatt's theories of evolution and heredity. To go deeper into the subject would, I fear, only introduce confusion into the mind of the reader.

The paleontologist possesses at least one advantage over the student of existing animals in that he may observe the changes that develop during thousands of generations, whereas the zoologist sees the present but dares not even vaguely guess upon the future of the race he studies. Accordingly, Hyatt made little impression upon zoologists, but some of the most brilliant paleontologists have applied his principles to the unraveling of the genealogy of fossil and living animals. We need only mention the classic studies of Professor Charles Emerson Beecher upon brachiopods and trilobites, or the many researches of Hyatt's former assistant, Professor Robert Tracy Jackson, at present one of the most progressive leaders of the Hyatt school, among whom are such active investigators as Bather, Buckman, J. M. Clarke, Cumings, Grabau, Ruedemann, Stanton, J. Perrin Smith, Burnet Smith, Schuchert and Van Ingen. In the untimely death of Professor Beecher in 1904, the school suffered a most serious and almost irreparable loss. The general attitude of zoologists toward Hyatt's theory of evolution is probably best expressed by quoting from two of the letters which Charles Darwin wrote to Professor Hyatt in 1872, in which Darwin says:

> After long reflection I can not avoid the conviction that no innate tendency to progressive development exists, as is now held by so many able naturalists, perhaps by yourself. . . . The longer I live the more I become convinced how ignorant we are of the extent to which all sorts of structures are serviceable to each species. But that characters supervening during maturity in one species should appear so regularly as you state to be the case in succeeding species seems to me very surprising and inexplicable.

Hyatt believed in the inheritance of acquired characters. By such he understood modifications which appear in adult or late stages of growth, and are due to the influence of external conditions and not caused by heredity. Probably the most interesting and important paper which Hyatt wrote is his "Phylogeny of an Acquired Characteristic" published in the *Proceedings of the American Philosophical Society* in 1893. In this he shows that at first the young shell in the nautiloids is nearly straight, but soon the shell bends around and grows over the outer side of its older part. The cross section of the young shell before it overgrows itself is round, but when it presses against its first whorl it is squeezed inward on one side, or impressed. This impressed region is due entirely to the pressure of the shell in overgrowing its older whorl, for in the Silurian and Devonian nautiloids the shell does not become impressed until it actually comes in contact with the older whorl, and is thus squeezed inward on its inner side as it passes around the outer side of its older part. That this is due solely to pressure is shown by the fact that when these Silurian and Devonian forms uncoil the impressed zone disappears at once in the uncoiled part, the cross-section of which is round as in the young shell before it grew over its first-formed whorl.

In the Carboniferous species *Coloceras globiatum,* however, the impressed zone appears in the young whorl *long before* it has touched and grown over its first whorl, and in the Jura *most* of the nautiloids develop an impressed zone before the shell touches its first whorl. As Hyatt states, the character has become hereditary and appears at an earlier stage than in the Devonian ancestors. There is also a quicker development of the coiling tendency in Jurassic shells and still more so in the Cretaceous.

It is hard to escape the conclusion that this is actually an acquired character which becomes hereditary, and finally appears at a stage earlier than that in which it first developed. Indeed, it is one of the classic instances of an acquired character, and one of the best established cases of this sort in the whole field of zoology.

In order to establish these interesting facts Hyatt was obliged carefully to crack apart a large collection of nautiloid shells to make a microscopic study of their earliest whorls.

In 1889, Hyatt published his final paper upon the "Genesis of the Arietidæ," a large family of the ammonoids. He agrees with Neumayr that three of the four great branches of this family are descended from a single species, *Psiloceras planorbe,* which was itself derived from *P. caliphyllum* of the northeastern Alps. The race then migrated into Italy, south Germany, and the Cote-d'Or in which last place new progressive forms migrated back again into the northeastern Alps and thence during Bucklandian and later times into parts of Germany,

Italy and central Europe. Hyatt carefully traces out the complicated genealogy of the related forms and describes their migrations, and his monograph is beautifully illustrated by heliographic plates. In order to carry out these studies, he visited the museums of Stuttgardt, Tübingen, Würzburg, Munich, Zurich, Paris, Semur, the British and Geological Society Museums of London, and other places in Europe.

In 1872–73, Hyatt lived in Würtemberg in order to study ammonites and also variations and evolution of the fossil snail shells *Planorbis* from the ancient Tertiary lake at Steinheim. As is well known, this lake gradually filled with gravel and limestone mud, and thus the later shells lived at higher and higher levels until the lake became wholly dry. Hyatt agrees with Hilgendorf that all of the species of *Planorbis* found at Steinheim are descended from four varieties of *Planorbis levis* which entered the lake in early times. At first hybrids were developed between these four varieties, but as the original stocks diverged more and more one from another, these hybrids died out. Hyatt finds that in all four stocks there is at first a tendency to increase the spiral of the shell due to a deepening of the lower at the expense of the upper umbilicus, thus eventually producing more or less trochiform shells. Hyatt states that the Steinheim shells develop similar species in many separate and distinct genetic series, and these parallelisms he ascribes to the fact that all lived in one and the same environment and were subjected to similar external influences. His genealogical series differ considerably from those of Hilgendorf, and the Steinheim shells must be restudied by some unbiased investigator before we can be certain of the facts in the controversy. Hyatt found that the young shells are always smooth, but in one race transverse ridges appear on the outer whorl and finally affect the inner whorls of their descendants. Uncoiling also appears first in the outer whorl and finally the inner whorls also uncoil, and in another stock a keel-like ridge forms first on the outer and afterwards extends to the inner whorls. Thus these characters are accelerated, *i. e.*, appear earlier and earlier in the lives of the descendants. Hyatt concludes that the modifications of the Steinheim shells are due to the law of heredity with acceleration, and are not controlled by natural selection, although natural selection may have caused the dying out of the hybrids between the four original varieties. He also believes that gravity produces modifications of structure, and that unfavorable conditions cause uncoiling, produce transverse ridges and diminish the size of the shells. He states also that "the tendency to earlier and earlier inheritance in successive generations is apparently the result of disturbing and modifying agencies acting from without."

For the last twenty years of his life Hyatt studied the mutations and migrations of those most interesting of variable snails the Achatinelidæ of the Hawaiian Islands, and, indeed, he was upon the point of

visiting Hawaii when death overcame him in 1902. It is very unfortunate that he never fully wrote out the results of his studies upon these shells, the manuscript which was found after his death being very incomplete, especially upon specific points, and although many of his descriptions of the species themselves were completed, yet his conclusions respecting their relationships and migrations are only vaguely referred to. He did, however, publish a short paper in *Science* in 1898 in which he finds that there are about 280 species of land snails on the island of Oahu, with three leading genera, *Bulimella, Achatinella* and *Apex.* All of these are probably descended from the recently extinct *Achatinella phœozona* of Kiliouou valley, whence they migrated northward, and are now found chiefly on the western sides of the range of mountains which extends along the eastern shore of the island.

Only a very few Achatinellæ crossed the broad lowlands in the middle of the island, and reached the range along the western coast. Species of *Apex,* however, crossed these lowlands and now thrive on the western range, but do not live well on the seaward face of either the eastern or the western range of mountains. The Bulimellæ are confined to the high parts of the eastern range, but have not crossed the lowlands, and are not found upon the western range of mountains. Hyatt saw that the Achatinellidæ of the Hawaiian Islands afforded a preeminently favorable opportunity for the study of the effects of physical conditions on structure. He knew the stock from which he could trace the migrations of the various descendent races, and he became familiar with the different physical surroundings to the effects of which these races were subjected. Thus he felt that he could demonstrate conclusively the effects of environment upon the structure of the shells, and perhaps upon the soft parts of the animals. This research would, had he completed it, have been his masterpiece, and would have added greatly to the world's store of knowledge.

In 1888, Hyatt published in the *Proceedings of the Boston Society of Natural History,* his final paper upon the "Larval Theory of the Origin of Cellular Tissues," in which he maintains that the metazoa are descended from colonial forms of protozoa, and the metazoa may be regarded as complexes of multicellular colonies in which growth by sexual union and resulting fission of the ovum leads to the formation of three primary body layers enclosing an archenteron. *Volvox* or *Eudorina* are forms intermediate between metazoa and protozoa, and may be called *mesozoa,* being multicellular colonies composed of only one layer of closely connected cells forming a primitive tissue.

Hyatt's scientific papers and published discussions cover a wide range of subjects and include such titles as the temperature of caves and wells; the absence of distinct marks of glaciation in Alaska; rock ruins at Niagara Falls; the chasms of the Colorado; a disintegrating

rock at Salem, Mass.; Atlantic shore changes; a raised beach at Marblehead Neck; the porphyries of Marblehead; geological survey of Essex County, Mass.; moulting of the lobster; malformation in lobster's claws; and biographical notices of George H. Emerson, Lucretia Crocker, Spencer F. Baird, Jules Marcou and T. T. Bouvé. Unfortunately, his style is confused, for he uses too many adjectives and subjunctive clauses, and rarely presents summaries of his conclusions. The complexity of his elaborate terminology also tends to deter the general reader, and he never sought to present his theories in simple language.

His productive period began immediately after the publication of Darwin's "Origin of Species" and ended just before the rediscovery of Mendel's law of heredity; thus he was one of the leaders in that active discussion of evolution during that speculative period which has now been superseded by direct experimental tests of the theory itself.

His last published papers are upon fossil cephalopods. In 1900, he completed the revision of the nautiloids and ammonoids for Eastman's translation of Zittel's "Handbuch der Paläontologie"; and after his death a manuscript upon "Pseudoceraties of the Cretaceous" was found lying upon his desk practically completed, he having written upon it on the last day of his life. This work was edited by Dr. T. W. Stanton and published as Monograph No. 44 of the U. S. Geological Survey in 1903. The last paper bearing his name was in cooperation with Professor James Perrin Smith upon the "Triassic Cephalopod Genera of America" and was published by the U. S. Geological Survey in 1905, consisting of 394 pages and 85 plates composed of photographic reproductions from the specimens themselves. For many years Hyatt was paleontologist upon the U. S. Geological Survey and these later papers were the results of his labors in this field.

He was elected to membership in the American Academy of Arts and Sciences at Boston in 1869 and was one of its vice-presidents at the time of his death. In 1875 he became a member of the National Academy of Sciences, and in 1895 of the American Philosophical Society of Philadelphia. He was also a foreign member of the Geological Society of London, and was associated with other leading scientific societies both at home and abroad. In 1898 he received the degree of LL.D. from Brown University, and he was one of the founders and the first president of the American Society of Naturalists.

His broad interest in all departments of knowledge, and his generous heart and kindliness to all about him caused him to be surrounded by a host of warm friends whose regard for him increased as years passed by. Thus it was that he was a prominent member of those remarkable social clubs of Boston which strove for the uplifting of humanity, and for the refining and perfecting of ideals of culture. Such were the Chestnut Street Club, a literary association numbering Longfellow,

Emerson and Holmes among its members; the Examiner's Club composed of intellectual and clerical men who met to discuss religious and scientific topics; The Thursday Club, a social and intellectual organization; and the Round Table Club, which was for years presided over by Colonel Thomas W. Higginson and met for the discussion of sociological, educational and political subjects. Another organization of intellectual men was known simply as "The Club" and met for discussions of many interesting topics at the houses of the various members, all of whom were Cambridge men, such as William James, Horace and Samuel Scudder, Putnam, Trowbridge, Gilman, Dr. Hildreth, Thorndike and Justin Winsor.

Hyatt was keenly appreciative of the natural beauty of the primeval American landscape which man had done so much to desecrate, and he was deeply interested in the conservation of the forests which still clothed our mountainous regions. Thus he was one of the original members of the Appalachian Club, and served as its president in 1887.

On January 15, 1902, he died suddenly of gout of the heart while he was standing in Harvard Square intending to leave Cambridge to attend a meeting of the Boston Society of Natural History. As Professor William H. Dall says in his biography published in 1902:

> No one who had the privilege of Hyatt's acquaintance but will join in testimony to his high-minded scientific integrity; the infectiousness of his hearty enthusiasm; the fertility of his imagination, which yet was always controlled by constant reference to experience and observation; and the general atmosphere of good-fellowship which he diffused. Unpretentious, open-minded, a constant example of clean living, high thinking and unassuming kindness to all about him, an ideal husband and father, a steadfast friend; we shall not soon look upon his like again.

He lived in a large wooden house built in the New England Colonial style on Francis Avenue in Cambridge. This place he named "Norton's Wood," for it was adjacent to the forest which still remained upon the old estate of Professor Charles Eliot Norton. The open-handed hospitality of his home was a heritage from his youthful years at "Wansbeck" in Baltimore, his house being a center for that delightful intellectual social life of the days when Cambridge still retained its traditions as a college town apart from the overwhelming influence of Boston. None of his three children sought to follow him in the study of science, although it may be of interest to observe that both of his daughters became sculptors, the scientific accuracy of their work being remarkable even apart from its artistic merit.

After his death, biographies were written by C. E. Beecher in the *American Journal of Science,* W. O. Crosby in the *Bulletin of the Geological Society of America,* Samuel Henshaw in *Science,* William H. Dall in THE POPULAR SCIENCE MONTHLY, and the Boston Society of Natural History published an account of the proceedings of its Hyatt Memorial

meeting, all of these appearing in 1902. In 1903, Professor A. S. Packard wrote an appreciative biography in the *Proceedings of the American Academy of Arts and Sciences,* and in 1904 T. W. Stanton wrote a sketch in the *Proceedings of the Washington Academy of Sciences,* and finally the late Professor William K. Brooks published a memoir of Hyatt in the "Biographical Memoirs" of the National Academy of Sciences, Volume 6, 1909, this paper containing a chronological list of the titles of his published papers. In 1885 a contemporaneous biography of Hyatt was published by Ralph S. Tarr in volume 28 of THE POPULAR SCIENCE MONTHLY.

IBSEN, EMERSON AND NIETZSCHE; THE INDIVIDUALISTS

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THE development of various phases of individualism is one of the striking phenomena of the nineteenth century. We are not yet far enough away from it to be sure how it will look to our eyes when it has become somewhat definitely measurable as the actual past, but it is not a wild conjecture to think that it will then appear as the individualistic century. In the world of letters Ibsen, Emerson and Nietzsche were three of the more significant, not to say the three most significant, apostles of individualism. They are interesting in comparison, because they represent quite different phases of the individualistic spirit and find their inspiration in somewhat different sources at the same time that they were contemporaneous and were each the product of a general tendency of their time. They illustrate that responsiveness to the common tone of an age that often surprises us in great men who have seemingly been not at all subject to the same specific influences.

There were three major subjects of human thought within which originated the presuppositions that were the foundation for individualism. These were religion, political economy and biology with its related sciences. When at the house of the centurion Cornelius in Cæsarea, Peter said that he perceived that God was not a respecter of persons, but that in every nation he that feared him and respected him was acceptable to him, the Christian religion was set forward on that course that was to bring man finally to a larger hope and trust for himself and all his fellows. For several centuries, for the first twelve hundred years following the founding of the Roman Catholic ecclesiastical system, indeed, the church meant little for either morality or the individual man. It was the church itself, its organization and its further establishment, that was of first moment, but with the Protestant reformation the fundamental Christian sense of human values at once became more active in society. When it became "the dissidence of dissent" in the new world and particularly when it became New England Congregationalism, that sense of value had made the individual human being of first importance in the world. That consequence of the development of protestantism was carried still further by the weakening of Calvinism in the New England churches and by the warmer recognition of the interest taken by the Son of God in every man, Jew or Gentile. It was not solely because New England

was in the north that the abolition sentiment was so strong there in the fifties. It was largely because in the eyes of New England congregationalism the black man had a soul, as, in the same sense and degree, he could not have to the eyes of the presbyterianism and the episcopalianism that were dominant in the south.

The growth of individualism as a part of the political activities originating at the close of the eighteenth century is so obvious and so familiar as to come well within the common knowledge of every one, but the contribution of science to this movement of thought in the nineteenth century is not so easily apparent. The first significance of the doctrine of evolution, the great contribution of biology to science in the nineteenth century, was doubtless that of a lessening of the dignity of man. The importance given to man in the expansion of protestant theology, in which he was more and more pushed forward to the honor of co-heir with Christ, was at once denied by implication in the thinking of the followers of Darwin. A creature that had risen out of the brute was very doubtfully filled with that divine essence that made him rightfully a ruler of the universe equally with all other men as being in the same degree with them one of the sons of God. Science here, therefore, gave individualism no promise upon which it could establish itself in the essential nature of man. On the other hand, the Darwinian presentation of evolution as a process did furnish such a premise in the process itself. It was through the struggle for existence that man had come to be man. In this struggle it was some quality or qualities of the individual that raised him above the mass and kept the evolutionary process going forward. That understanding of the nature of the forces that shape life for us transformed the conceptions of the last century and put a new emphasis upon social efficiency in the individual as the first element of progress. In the United States all of these influences, the freedom of extreme protestantism in religion, the general doctrine of political and human equality, and the acceptance of the principle of evolution, have been more free than elsewhere to combine in producing an extreme form of individualism. Of these several influences, however, the spirit of an advanced protestantism seems to have been the most distinctive and the most peculiarly active.

It is as an ultimate product of the most liberal and progressive religious thinking of the new world that Emerson is an individualist. It is also, to be sure, as a philosopher working out in his own way a transcendentalism that goes back to Kant, but the philosophy is so deeply interpenetrated with religious feeling and is so largely turned aside to religious uses that we may call it religion. Everywhere, however, it is the religion of the individual soul, a religion that finds its support in an unfaltering faith in the worth of the individual. In "Self-Reliance" he says:

Let a stoic arise who shall reveal the resources of man and tell men they are not leaning willows, but can and must detach themselves—that a man is the word made flesh—and that the moment he acts from himself, tossing the laws, the books, idolatries and customs out of the window—we . . . thank and revere him.

Further on in the same essay he says again:

The secret of fortune is joy in our own hands. Welcome evermore to gods and men is the self-helping man. For him all doors are flung wide. Him all tongues greet, all honors crown, all eyes follow with desire.

This is all open and unmistakable individualism, and that it is individualism on the religious basis is clear when, in the same connection, he speaks of a greater self-reliance as "a new respect for the divinity in man."

This, indeed, is in an essay that suggests the note of personal aggressiveness, but we shall not find it otherwise in the essays on "Love" and "Friendship." In the one he says:

Thus we are put in training for a love which knows not sex, nor person, nor partiality, but which seeketh virtue and wisdom everywhere. . . . We are often made to feel that our affections are but tents of a night. Though slowly and with pain, the objects of the affections change, as the objects of thought do.

In the other he says as the conclusion of the whole matter:

I do then with my friends as I do with my books: I would have them where I can find them, but I seldom use them. We must have society on our own terms, and admit or exclude it on the slightest cause. I can not afford to speak much with my friend. If he is great he makes me so great that I can not descend to converse.

Here even the offices of what are normally the most unselfish of the personal relations of life are conceived of as having their aim and end in the development of self. Life finds its fulfilment in an approximation to the divine possibilities that are the natural heritage of every human being, and in attaining to that one must not permit himself to be materially hindered by consideration for others. Part of the divine perfection is doubtless expressed for Emerson in the Sermon on the Mount, but it seems clear that he contributes his share toward that questioning of the ethical system of Christianity which now centers upon that portion of the gospel. He does not put himself explicitly in opposition to the beatitudes, but he exalts a spirit and a philosophy in which their teaching is more or less negligible. This, perhaps, is little more than saying that with Emerson protestant theology had passed out of the stage of bondage to the letter, but the forces at work in the change were those of a deeper regard for the powers and capabilities of the inner man, a deeper wish that there should be no check upon their expansion to their fullest possibilities. How large these were in his conception of them may be seen in the essay on "History."

I can find Greece, Palestine, Italy, Spain and the Islands—the genius and creative principle of each and of all eras, in my own mind.

It was in the same spirit that he spoke slightingly of travel. Man could find nothing in foreign countries beyond what he took there, because, if he would be fully himself, if he would bring himself to completion, he would find the whole world in himself. That was the sufficient warrant for feeling that society was not important, but man the individual, man, too, not as in society and a part of it, but man as a separate entity realizing his kinship with the divine in his own way for himself.

There is this same word again in the conclusion of "The American Scholar."

> Is it not the chief disgrace of the world, not to be a unit—not to be reckoned one character—not to yield that peculiar fruit which each man was created to bear, but to be reckoned in the gross, in the hundred, or the thousand, of the party, the section, to which we belong? . . . We will walk on our own feet; we will speak our own minds. . . . A nation of men will for the first time exist, because each believes himself inspired by the Divine Soul which also inspires all men.

The background for the individualism of the German philosopher Nietzsche was in most respects very different from that of Emerson. There was this much in common between them that they both came of clerical stock and that in a way they both reacted from the religious bias that seemed so to have been given to their lives. Beyond that superficial resemblance in the influences playing upon them, they differed radically in the way in which they responded to the teachings of Christianity. Emerson may be said to have been a natural development of the puritan spirit, unique, iconoclastic, reconstructive, to be sure, and yet a puritan clergyman, who, as Woodberry says, never wholly escaped the black coat. In every fiber of his being he was first and last a moralist, one who passed out of the negations of puritanism to its affirmations, and yet essentially a puritan moralist. The one thing that most marks Nietzsche's individualism, that distinguishes it vitally and unalterably from Emerson's, is its intense opposition to Christian morality. This hatred of the whole Christian system has its ground in his conception of Jewish morality as a slave morality. Christian ethics are, to his view, the product of a religious system and teaching, the end and purpose of which is that of giving weakness an advantage over strength, of making the slave the ultimate lord of his master, of raising a subject race to a sense of triumph over its enemies and conquerors. This to his mind is a monstrous perversion of things, for, as he says in "A Genealogy of Morals":

> To demand of strength that it should *not* manifest itself as strength, that it should *not* be a will to overpower, to subdue, to become master of, that it should *not* be a thirst for enemies, resistance, and triumphs, is as absurd as to demand of weakness that it should manifest itself as strength.

This demand is the demand of the Christian system, and, to quote Nietzsche again from the same volume:

> It was the Jews, who, with the most frightfully consistent logic, dared to subvert the aristocratic equation of values (good = noble = powerful = beautiful = happy = beloved of God), and who, with the teeth of the profoundest hatred (the hatred of impotency), clung to their own valuation: "the wretched alone are the good; the poor, the impotent, the lowely alone are the good; only the sufferers, the needy, the sick, the ugly, are pious; only they are godly; but ye, ye, the proud and potent, ye are for aye and evermore the wicked, the cruel, the lustful, the insatiable, the godless; ye will also be, to all eternity, the unblessed, the cursed and the damned.

This is what Nietzsche calls the slave revolt in morality, and with the present triumph of the Christian system that here had its source he sees a transformation of the values of the terms good and bad that has been more or less destructive of the fine ideals of the human race. Evil has gained the upper hand. He says again:

> The two antithetical values, "good and bad," "good and evil," have fought a terrible battle, a battle lasting thousands of years. . . . The symbol of this struggle, in letters which remained unreadable above the entire history of man until now, is called "Rome against Judea, Judea against Rome." So far no greater event has occurred than *this* struggle, *this* question, *this* deadly inimical antithesis. Rome felt in the Jew something like the embodiment of anti-naturalness, its anti-podal monster, as it were; in Rome the Jew was looked upon as "convicted of hatred against all mankind"; and rightly so, in so far as we have a right to connect the welfare and future of mankind with the unconditional dominance of aristocratic values, Roman values. . . . The Romans, we know, were the strong and the noble, so that stronger and nobler men had never existed on earth before, nay, had not even been dreamt of. . . . The Jews, on the contrary, were that priestly class of people of resentment *par excellence*, which was possessed of an unparalleled, popular ingenuity of morals.

It was as an intellectual aristocrat, a believer in aristocratic values, that Nietzsche set forward in his development as an individualist. He began his life work as a philologist, and Greek was his especial philological interest. His studies in this field brought him under the influence of Greek ideals of power and beauty, dionysiac ideals of abandon, of unrestraint, of free joy, as opposed to the moral conceptions involved in the worship of Apollo. This point of view appears in his first philosophical book, "The Birth of Tragedy." In its first form this title had the additional phrase, "out of the Spirit of Greek Music," and this is significant as revealing his sense of the greatest of the arts as having its origin in the vague and wandering impulses of free feeling rather than in moralizing and reflective thought. Here was the origin of that sense of final values upon which his philosophy is built. The thing of most worth in the world is not the average man and his happiness, but the select man, the man who answers Yea to all of life, the man who takes tribute of

other men and lives gladly and freely and fully, obeying his instincts and ignoring the common priest-taught, slave-born distinction between good and evil. Power, intellectual and physical, the power to do a thing, to conquer others, to use men of less power for his own ends, is the mark of an excellence that should suffer no check from the plebeian teachings of a Jewish and slave morality.

To the influence of the Greek spirit as Nietzsche felt it there was added the influence of Schopenhauer to whom he was indebted for his conception of the highest instinct of man as being "The Will to Power." For him this will to power is so fundamental a part of the natures of all men of the higher sort that he finds in it the motive for the imposing of punishment upon those who injure the state or their fellow men. He says:

> By the administration of punishment against the debtor the creditor will become a sharer in a *privilege of the master*. At last he also will for once be inspired by the elevated feeling of being allowed to despise and maltreat somebody as being "lower than himself," or, at any rate, in case the proper power of punishment, the executive power, has already passed to the authorities, the feeling of seeing him despised and maltreated.

This is but one phase of what he calls "the true nature and function of life, which is *will to power*." We hear a great deal lately of the superman, and we are likely to associate the conception with the name of George Bernard Shaw, but he has borrowed it from Nietzsche. If the select few are left free to exercise this "true nature and function of life," as they will, they may develop into an order of beings of higher tastes and greater powers than are exhibited by man in the present. This process, however, can not go on to the evolution of the superman as long as society is under the dominance of a slave morality of which the first consequence is a transformation of values by which the humble and the lowly and the weak are made the equals of the strong and the victorious and the successful.

Of this individualism in Nietzsche it is to be observed first that it is based primarily on a personal predilection. The circumstance that Nietzsche finds some human qualities admirable and others contemptible is not a sufficient ground for the establishment of a system of ethics or philosophy. A preference for the Roman over the Jew is, after all, but a preference, and Nietzsche does not sufficiently show that it is founded in some clear superiority of one over the other as determined by some recognized standard of worth. In the same way he is personal and dogmatic in declaring that the will to power is the true nature and function of life. He cared for power, but it is not a necessary corollary from that fact that the gratification of the will in the pursuit of power is the distinguishing mark of the nobler man. Nietzsche's individualism here must have another support beyond that of his own sense of values. It happened that just at this time science was presenting a

theory of the world order of things that offered the required basis for his views.

Nietzsche frequently displays an antipathy for English thought, irritated apparently by its practical and utilitarian leanings. Nevertheless it was to an Englishman, Darwin, that he was indebted for the substantial support that his thinking needed. It is not evolution, however, that is the support of the Nietzschean individualism, but the Darwinian process of evolution. The thing that is inseparably bound up with Darwinism is the doctrine of the struggle for existence. If we accept the struggle for existence as the most important, or even as a vital factor in the process of evolution, then we may accept Nietzsche's will to power. The one is the reflection in philosophy of what the other is in biology. It is the application to human life of a biological sense of values. The man actuated by the will to power is the one that, succeeding in the struggle for existence, will carry the evolutionary process forward. It does not matter that this idea did not originate in this way in Nietzsche's mind. However personal and illogical it may have been in its inception, we shall yet have to give it a hearing, if we can be assured that it is but the expression in new terms of an established scientific truth so generally accepted in one department of knowledge as to be of universal application in all departments. That is a vital question, vital, not for Nietzsche alone, but also for all of us in all our thinking while we are yet a part of that struggle between individualism and collectivism of which the world will not for a long time see the end.

It is to be borne in mind that there is no general question now of the actuality of evolution, but within the last twenty years there has developed among biologists a wide-spread distrust of Darwinism as an explanation of evolution. It would not do to say that selection and the struggle for existence have been disproved as sufficiently revealing the method of evolution, but they have been very largely discredited. Instead of the Darwinian explanation of the method of evolution there have been proposed a great many other explanations, and those accepting these various theories have naturally been active in showing the weaknesses in Darwinism. In other words, the presuppositions upon which individualism founded itself in Nietzsche's philosophy and in the thought of the world have been very seriously undermined. No one will be so bold as to deny that now as we finish the first decade of the twentieth century, along with the weakening of our faith in the survival of the fittest, we are witnesses of a pronounced lessening of the power of individualism over the human mind. Nietzsche, individualist of the most extreme type though he was, is probably read more than ever, but interest in him is rather interest in what men have thought than interest in what they are still thinking. A recent sign of the reversal of our feeling in this matter is observable in the wide-spread

adoption of the Galveston or Des Moines plan of city government, a plan which looks toward organized social efficiency more than it does toward the preservation of individual rights. Nietzsche died in nineteen hundred, too early perhaps to realize that the scientific foundations for the work of his life were crumbling beneath his feet.

Emerson's death occurred in 1882. It must have been then even less clear that the theological basis for his philosophy, if it may be so called, was also in no very long time to lose much of its weight. The idealism that in unitarianism lifted man up to the level of Christ soon wrought a kind of self-destruction by bringing Christ down to the level of man. The exaltation of man, of his individual greatness through his kinship with the divine that was Emerson's especial word ceased to be an exaltation when it reduced the divinity of Christ to a merely human greatness. Protestant theology, going forward to its ultimate conclusions, accepting the results of the higher criticism, studying the Bible as a great but as a human literature, compromising with evolution as a causo-mechanical explanation of the origin of things, finally leaves Emerson's individualism without any sufficient body of supporting voices in the house of his friends. There remain, to be sure, the christian scientists. They derive from Emerson, and, with a beautiful blindness to the results of both christian scholarship and the conclusions of modern science, they push the Emersonian ideas to a point at which they become nonsense. Theirs is a beautiful madness, but it is madness. They represent only the aberrant tendencies of more or less unbalanced minds. Their belief that each human being may be the master of himself, his body and the material world, may be himself a kind of God, if he wills, does not go far in support of individualism as a general feeling among men. It was otherwise with Emerson. He and those of his fellowship were enormously influential in American thinking. It may be doubted whether any other man has been equally important in shaping the ideals of the more intelligent classes in America. It is something of moment when on one side that influence is breaking down and on another is turning into the vagaries of people who clutch at cobwebs spun out of the froth of some fanatic's ravings.

One thing is to be borne in mind and that is that the truth or falsity to be found in either Emerson or Nietzsche is for the moment of no matter. It is sufficient as explanation of the growing preponderance of socialistic over individualistic tendencies to show that two of the fundamental inspirations for individualism as seen in them are materially less active forces in society than they were twenty or thirty years ago. If that were mere change of sentiment, it would be of less importance. The fact that it is not sentiment, that it is a change of front resultant from a changed understanding of what the world is for man, and that it is a new establishment of values of things for man to achieve and be

makes it significant. A decade or two makes now such an addition to the body of facts that come into the range of human knowledge that the effect may be complete subversion of previously entertained opinions except in the case of men whose sentiments are so strong that they cling to what they have believed the more tenaciously the more it is assailed. Public opinion as a whole shapes itself in agreement with the new facts. It is new facts and fuller interpretation of the old facts, not merely a refluent wave of human feeling, that is responsible for the current trend away from individualism.

Ibsen died in nineteen hundred and six, and so he must be reckoned as of both the nineteenth and the twentieth centuries. He was an old man then, however, over twenty years older than Nietzsche was when he died, and naturally the real body of Ibsen's work was done by the end of the nineteenth century. Nevertheless, he was a man whose thoughts looked forward to our day as Emerson's did not and as Nietzsche's did not. He was an individualist as they were, but he was not an extremist, he was not a man to see the world from one view-point only, he was not narrow or intellectually provincial. That he went with the current ideas of his time as fully as either Emerson or Nietzsche, however, is easily apparent, and it is quite as clear that he was intensely an individualist. What could be more thoroughly individualistic than the words with which Dr. Stockmann ends "An Enemy of the People"? "You see," he tells his wife and children after the utter defeat of all his plans for the good of the community, "You see, the fact is that the strongest man upon earth is he who stands most alone." The two plays that probably more than any others have interested the general reading and play-going public, "Ghosts" and "A Doll's House," are both of them declarations—positive and negative, of the same thing, the right of the individual to develop his own life in his own way according to the needs of his own nature without too close a regard for the demands of society. When at the end of "A Doll's House" Nora is leaving her husband and children and Helmer protests that before all else she is wife and mother, she answers: "I no longer think so. I think that before all else I am a human being just as you are; or at least, I have to try to become one." It is in fact just the individualism in this play and in these words that has made it in a sense the distinctive and notable play of the nineteenth century. It is a human cry for emancipation, for freedom, for self-realization, and it is a cry that Ibsen reiterates again and again through his dramas, demanding that man shall realize himself, but also that he shall realize his best self. It is his peculiar virtue as an individualist that he is held back more or less by the feeling that no man realizes his best self without taking his fellows very largely into account. That is the summing up of his word in "Brand."

Ibsen can not be reduced to a formula. In a measure we may so deal with both Emerson and Nietzsche. We can express the one with some completeness in the term "the oversoul" and the other in the phrase "the will to power," but it was Ibsen's nature to look more carefully at both sides of the shield. That seems to have been the consequence not so much of any greater sureness or clarity of thinking as of a wider range of human sympathies. Emerson wrote beautifully about friendship, but he did not concern himself greatly about his immediate relations with his friends. It was difficult to engage his interest deeply in the affairs of the community or the state or the nation. It seems a fairly reasonable assumption that any man who, theoretically or in fact, is to determine the forms that life as a social whole shall take must be a man who has a deep interest in his fellows, a man of warm social instincts. Only as he is such a man can he come to understanding of those things that man demands in his social order, and no social order can succeed unless it founds itself as carefully upon man's instincts and needs as it does upon the laws that man has discovered in nature. Ibsen felt this as apparently neither Emerson nor Nietzsche did. He was alive to all the political and social movements of his time, and so, because the basal motives of his thinking were rather political than religious or scientific, there was always in his thinking a glance at the whole of society. This kept him full-visioned and sane, and it must be this that Arthur Symons means when he says of him:

> He has less courage than Nietzsche, though no less logic, and is held back from a complete realization of his own doctrine because he has so much worldly wisdom, and is so anxious to make the best of all worlds.

Here we have the significant thing about Ibsen, and it is in this that he is a larger man than either Emerson or Nietzsche, at once an individualist and also a thinker conscious of that check upon the rampant individualism of a Nietzsche that we now feel necessary for the making of the "best of all worlds." Bernick in "The Pillars of Society," seeing that he has not realized himself because he has not sufficiently felt his obligations to society, says:

> Do you know what we are, we, who are reckoned the pillars of society? We are the tolls of society, neither more nor less.

Such a generalization understood as Ibsen meant it, has in it a profounder truth than anything in either Emerson or Nietzsche and it is a truth more immediately in accord with the spirit of the new century whose first years saw him a weakening and a dying man. In the loss of that divine made human in us of which Emerson dreamed we are only men once more, and it is as men that we must make the best of our world, if we do not make it the "best of all worlds." As evolutionists we must at last realize, it seems clear, that the struggle for existence is not and never again can be a blind struggle. Darwin made man a

conscious factor in the struggle as soon as he told him that there was such a struggle. As such a conscious factor he is certain to realize more and more that he is able to push the evolutionary process on only as a part of the social whole. It is the gregarious instinct in man that makes him the lord of the brute and civilized man the lord of the savage. So, while the biologist lessens the struggle for existence as a recognized factor in evolution, man nullifies it in organized society for those within the organization, and leaves it to work what havoc it will outside. This is on the way from individualism to socialism, and that is the way we are now going because of our new premises in religion and science and politics. Man, the single man, is to be steadily more and more, no doubt, but it is man in the collective whole that in this century is to croon over him as, in Ibsen's " Peer Gynt," Solveig at last croons over that poor wreck of self-realization gone mad, Peer Gynt himself:

> I will cradle thee, I will watch thee;
> Sleep and dream thou, dear my boy.

PHYSIOGNOMY AND GENIUS

By CHARLES KASSEL
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SAYS Edwin Miller Wheelock in that great prose epic of evolution which he called *Proteus:*

Our humanity has been evolved out of the lower and coarser types of life and faces still hang out the signs of this experience in the vulture beak, the bull-dog visage, the swinish aspect. This face is a bear's muzzle; that a snout. This one is written over with a foulness that needs no label; here is a rat and there an abject thing cringing for leave to be. The old brutehood lurks in each cerebellum and the nobler faculties of man sleep in their shell.

Since the uprise of the theory of evolution with its emphasis upon the physical tokens of kinship between man and the animals, the old science of physiognomy, which formed a favorite study of the ancients, and to which the great Aristotle himself devoted six weighty chapters, has come forth from its hiding amidst the discarded superstitions of the past. The time-worn rules for determining character from countenance have gained a genuine interest for the scientific mind, and even the old saws and proverbs—crystallizations of mankind's observation of faces and features for unnumbered generations—have taken on a dignity and value which they could not else have borne.

It is to the criminologists, however, that we are indebted for the first distinct step toward a scientific study of physiognomy, and their labors give hint of the large results which might be possible to an investigation of wider scope. Thus, we are informed by Havelock Ellis, in his interesting and instructive work "The Criminal," that the receding forehead, prognathous jaw, and long, projecting and voluminous ears are in general characteristics of the criminal, while, according to Lombroso, the homicide may be known by his cold, fixed and glassy eye, beaked nose, prominent jaws and cheek bones, thin lips, and, not infrequently spasmodic contractions on one side of the face. "Among petty criminals, those who are criminals by weakness," says Ellis, "a type of receding chin is found," and he adds, "the typical thief's nose is rectilinear, often incurved, short and twisted, with lifted base."

Deep-rooted as is the instinct for inferring character from countenance, it is not a little remarkable that the one ripe and ready field for the study of physiognomy has remained thus long unexplored. The pages of biography should afford rich spoil for the curious delver after hidden laws of mind and morals, and it seems that a tabulation of the faces and figures of eminent personages should long since have suggested itself as desirable, if not indispensable.

Truth to say, however, no ingathering of such data appears to have been made, or, if made, to have been given publication; and, failing statistics at second hand, we have endeavored by search at first hand through some two hundred biographies, to supply the want—less, be it added, as a basis for generalization upon our own part than as an offering of material for study and analysis by others.

The feature of the countenance which first strikes the observer is the eye—the "lamp of the body" as it is called in the new testament, but more fitly, perhaps, the "lamp of the soul," for in very truth the eyes are the lighted portals to man's inner nature. The most noteworthy circumstance which our data offer is the very large predominance of blue, gray and bluish-gray eyes among personages of distinction. Thus, of seventy-six eminent men whose biographies afforded the information, twenty-five appear to have had blue eyes, seventeen gray and thirteen bluish-gray, making a total of fifty-five. Boasting eyes of blue—the color-symbol of goodness, according to the mystics—were Samuel Adams (dark blue), Matthew Arnold, Charles XII. of Sweden (dark blue), Longfellow, Stephen A. Douglas (dark blue), Eugene Field, Stonewall Jackson ("as a child, blue-eyed"), Charles George Gordon (pale blue), Patrick Henry, Oliver Wendell Holmes, Andrew Jackson, Charles Godfrey Leland, Washington Irving (given as gray by some biographers), Washington Alston, James Monroe (blue, approaching gray), Napoleon ("steel blue"), John Ruskin, Savonarola (dark blue), Wm. H. Seward, Shelley, Chas. Sumner ("deep blue"), General Thomas, Grieg, Weber. Among gray eyes—"deep and sly" if we are to heed an old proverb—we have Michael Angelo ("light eyes"), Browning, Cæsar (variously given as dark gray and black), Carnegie, Coleridge (described by other authorities as light hazel), Columbus (light gray), Sir Thomas More, Wm. Hazlitt, Ibsen (pale eyes), Washington Irving (dark gray but, according to others, blue), Thomas Jefferson ("gray flecked with hazel"), Milton (dark gray), Francis Parkman, S. S. Prentiss (dark gray), Robespierre ("pale greenish gray"), Tolstoy, Tennyson (this according to Caroline Fox, but, according to Carlyle, hazel). As representing a blend or play of both colors we have the names of George William Curtis, Charles Darwin, Frederick the Great, U. S. Grant (according to some biographers "dark gray"), Walter Savage Landor, Sidney Lanier, Napoleon (given by others as steel blue), Longfellow (given by other authorities as blue), Theodore Parker, Rossetti (between hazel and blue gray), Thoreau, George Washington, Whitman. It will have been noted that the same name appears occasionally in two of these lists This is owing to a conflict between biographers and the same circumstance will explain a like duplication in future lists.

The brown-eyed men among the celebrities of history were Captain Cook, Goethe (dark brown), Keats (hazel brown), Charles Lamb, R. L.

Stevenson, Bayard Taylor (dark brown), William the Silent and Chopin. The eyes of Rufus Choate, Alexander Hamilton, Fielding, Sir Arthur Sullivan, Beethoven and John G. Whittier are described as "dark," Whittier's being described by most biographers as black. Hazel-eyed were S. T. Coleridge (given variously as hazel and gray), Farragut, Albert Gallatin, Hobbes, Keats (hazel brown), Walter Pater (light hazel, almost gray green), Southey (dark eyes, in youth light hazel), Tennyson (gray, according to Caroline Fox). Black eyes gleamed, according to biographers, from the brows of Cæsar (by others, however, spoken of as dark gray), Leigh Hunt, Paul Jones, John Marshall, Peter the Great, George Ripley, Daniel Webster and John Greenleaf Whittier.

With Agassiz, Peter the Great, R. L. Stevenson and George Washington, the eyes were set well apart, but precisely the reverse was true in the case of Robespierre. The eyes of Browning, Charlemagne, Coleridge, G. W. Curtis, Eugene Field, N. Hawthorne, Paul Jones, Napoleon, Peter the Great, Shelley and Tennyson were large—betokening, according to the "Encyclopedia of Superstitions," a faculty for talking and "for the use of effective language"; whereas those of Captain Cook, Patrick Henry, Ibsen, John Marshall, Tolstoy, Whitman, Chopin, Beethoven and Michael Angelo were small. As possessed of deep-set eyes—surrounded in the majority of instances by high arching eyebrows—we have the names of George W. Curtis, Darwin, Stephen A. Douglas, Eugene Field, Fielding, Gladstone, Alexander Hamilton, Patrick Henry, Huxley, Thomas Jefferson, Andrew Jackson, Paul Jones, Landor, Thoreau, Tolstoy, George Washington, Daniel Webster and Whitman. A profound power of observation appears to link with these names—an impression made more marked by shaggy eyebrows in the cases of Curtis, Darwin, Douglas, Jackson, Tolstoy and Whitman.

Next after the eyes, perhaps, the feature of the countenance which impresses the beholder is the formation of the jaw. Even before the lines of the mouth this aspect of the face engages attention. By no mere coincidence, doubtless, does a powerful jaw—the emblem of indomitable will—form the distinguishing marks of such physiognomies as those of Carnegie, Stonewall Jackson, Frederick the Great, Chinese Gordon, Grant, Alexander Hamilton, W. S. Landor, Walter Pater, George Washington, Arthur Sullivan and Schumann, nor does it seem without significance that in the case of Robespierre "an insufficient development of the jaw" is noticeable, and that in the case of Michael Angelo the "lower part of the face was much smaller than the upper." Quite suggestive, moreover, of something primitive, akin perhaps to ferocity, are the high cheek bones of the great navigators Columbus, Captain Cook and Farragut, on the one hand, and Robespierre and Daniel Webster on the other.

The lines of the mouth we never neglect. We naturally scrutinize the lips for impressions of power or weakness, coldness or affection, sensuality or delicacy. Our data here are less full than could be wished. We have no means of trying by the testimony of biography the dislike we feel for lips that are excessively full or which, when smiling, turn upward at the corners, nor can we verify the impression of extreme narrowness and obstinacy which we gain from feminine lips that are thin and bloodless and drawn downward at the end. We seem, however, to discern a marked austerity in the meager lips of Rufus Choate, Farragut, Stonewall Jackson, Frederick the Great, Ibsen, Robespierre, Thaddeus Stevens ("thin upper lip"), U. S. Grant and Paul Jones, whereas in the ampler labia of Coleridge, Cromwell ("strict yet copious"—Carlyle), Nathaniel Hawthorne (full under lip), Oliver Wendell Holmes (protruding under lip), Julian (full lower lip), Peter the Great, Savonarola (full under lip), Beethoven (protruding under lip) and Schubert we might suspect a proneness to self-indulgence. The long upper lip of Landor gives a suggestion of assertiveness and tenacity which seems unmistakable.

Quite disappointing are our data with reference to the chin. That feature would seem entitled to greater weight in any estimate of character than biography appears to warrant. Thus, the chin of long, square, shovel-like structure always drives in upon us a vague shrinking, as from something fanatical, and so a thin and pointed or receding chin carries a suggestion of weakness which moves our pity or contempt; yet such inferences seem unjustified when applied to the distinguished individuals of history, though even our scant data are not without a testimony to general characteristics of disposition as associated with set types of chin.

The chin of Oliver Wendell Holmes, as we find, was decidedly retreating, that of Hawthorne is pronounced "weak"; Defoe and Robespierre had sharp chins, while that of Fielding is described as "unusually long," that of Napoleon "projecting" and that of Parkman as "of unusual prominence." As round or full—a contour pleasing to the eye—we have those of Captain Cook, Charles XII. of Sweden, Eugene Field, Washington Irving, Sidney Smith and Thoreau, which last is described as "strong."

The nose we seem instinctively to look upon as a decisive index to character. We never think highly of the character or capacity of persons with small pinched noses. Pug noses, moreover, we associate with pertness, and long, pointed noses with inquisitiveness. So, the hawk-nose, to most observers, is a sign of an aggressive, self-sufficient nature, not troubled overmuch with moral scruple. We never look for a placid temper among persons whose noses roughen easily into wrinkles, and in those whose noses wrap into long folds down the

sides we expect evidences of a sordid make-up. Fine Greek noses, however, we take to be sure indications of good taste—large, shapely Roman noses as signs of solid character, inclining to generosity and capable of wise leadership.

These characterizations, however, seem but dimly borne out by the pages of biography. Thus, as possessed of small noses, we find Stephen A. Douglas, Oliver Wendell Holmes, Thomas Jefferson, James Russell Lowell, Peter the Great, Robespierre, Bayard Taylor and Thackeray (that of Schubert is spoken of as "upturned" and was doubtless small), while the large nose finds representation in the case of Charles XII. of Sweden, Eugene Field, Albert Gallatin, Washington Irving, Rossetti ("large distended nostrils"), Thoreau ("huge"), Tolstoy ("broad"), George Washington ("long in proportion to his face"), William the Silent ("long with wide nostrils"), Beethoven ("rather broad"). The hawk-nose was a characteristic of the warriors Charlemagne, Cromwell, Farragut and Frederick the Great, as also of Columbus ("aquiline"), Defoe, Fielding, Nathaniel Hawthorne, Lamb, Lanier, Savonarola, Sidney Smith, Thaddeus Stevens, Bayard Taylor and Chopin. The straight nose is found in the cases of Captain Cook, Albert Gallatin ("long and prominent"), Alexander Hamilton ("long and rather sharp"), Washington Irving, Paul Jones, Julian, Napoleon and Whitman.

Far more interesting and significant is our material with reference to the foreheads of great men—that popular test of intellect and capacity. Remarkable for high foreheads were Bunyan, Charlemagne, Charles XII. of Sweden, Darwin, Hazlitt, Patrick Henry, Hobbes, Leigh Hunt, Ibsen, Washington Irving, Andrew Jackson (high but narrow), Peter the Great, Robespierre, Walter Scott, Daniel Webster, Beethoven and Schubert. As "broad" we find the foreheads of Carnegie, Agassiz, Charles XII. of Sweden, Captain Cook, Stephen A. Douglas ("massive"), Nathaniel Hawthorne ("massive"), Washington Irving, Paul Jones, Keats (but not high), Lamb, Monroe, Robespierre, Rossetti, Savonarola, Walter Scott, Stevenson, Beethoven. The forehead of U. S. Grant is described as "square"—usually accepted as a proof of fearlessness—while those of Coleridge, Whitman and Michael Angelo are described as "overhanging." The foreheads of Frederick the Great and Robespierre were receding, while those of Keats and John Marshall were low.

It is not without interest that among the physiognomies of the distinguished individuals whose biographies we have examined, we note as conspicuously absent the "prognathous jaw" and "long, projecting and voluminous ears," which according to Ellis are characteristics of the criminal class, and which, it may be observed, are likewise tokens of recurrence to the primitive human type; nor in our studies of the

nose have we met the peculiarities of that organ which make up what Ellis calls the "typical thief's nose." An occasional mark of the lesser criminal, such as the receding forehead and retreating chin, make their appearance in our data, and those signs of power in the homicide —the prominent jaw and cheek bones, hawk nose and thin lips—are not without place in the faces of great historic characters, but with a single exception we find no example of the "cold, fixed and glassy eye" which according to Lombroso betokens the murderer. That exception, it is needless to say, is Robespierre, and it is no mean commentary upon the value of such studies as we have been pursuing that the face of Robespierre presented as strange a compound as his soul—that with the signs of strength afforded by the capacious forehead and firmly compressed lips there mingled so many features which the specialists in criminology accept as indications of criminality. His head, we learn, was small, brow retreating, nose diminutive and quite without an arch, jaw insufficiently developed, cheek bones high, eyes set close and in hue a "pale, greenish gray," shadowed by eyelids which trembled spasmodically.

GEOGRAPHIC INFLUENCES IN THE EVOLUTION OF NATIONS

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The Study of Nations.—The study of the chief nations of the world, with respect to their history, government, institutions or people, forms the basis of most of the humanitarian, as opposed to the natural, sciences. Yet in many respects the general attitude adopted in the interpretation of national development has not changed with the advances made in the scientific understanding of the earth in its relation to life. Fifty years ago, for example, the belief was prevalent that the earth was made for man's convenience. Since then the students of the natural sciences have adopted the conception that life is the product of evolution, in which physical conditions are at all times important factors. The study of nations, on the contrary, is still largely carried on from the old point of view, with little or no open recognition of the significance of evolutionary factors.

National Evolution.—For the nation, also, as well as for the individuals of which it is composed, physical conditions are at all times important influences. This principle of evolution, therefore, may be applied to the different stages through which human groups pass in their rise from primitive tribes to modern nations, in the same way as it is applied to the human individual in the evolution of man to his present high estate in the animal kingdom. Thus as the course of human progress replaces the isolated, self-dependent savage by the tribe, or any primitive group, the qualities and motives of the group reflect the needs which arise from the surroundings and also the opportunities at hand for satisfying these needs. The organized hunting tribes of forest dwellers, the pastoral nomads of open grassy plains, the fishing folk of barren coast lands, represent great advances beyond the first savage individuals, yet each of these groups is none the less the combined result of human needs and natural opportunities to gratify needs. Physical conditions are for these groups the most important factors in determining both the character of, and the opportunities for satisfying, human needs.

Each of the above groups represents a stage of progress toward national existence, but no one of them, as they stand, possesses the physical conditions necessary to lift the tribe to the higher plane where it might be said to have true national qualities. Before any primitive group can develop into a nation, it must be given an evironment where-

in it may be established and maintained on a permanent basis, with the returns from human efforts exceeding the demands of immediate needs. Under favorable conditions the cultivation of the soil offers such a chance for permanent establishment. Hence agriculture becomes the broad basis on which the development of important nationality may be said to depend, and an environment which permits agriculture is to be considered as a fundamental requirement for a budding nation.

Each nation, in every stage of its development, finds itself confronted by needs which must be satisfied, and it is forced to seek ways of gratifying those needs in order to preserve the national existence. Each nation, occupying its political unit, has in that unit certain natural opportunities which are the result of physical conditions, and which represent the sum total of means available to meet national needs, either directly or indirectly. Hence, each nation in its different stages of past development, in its present organization, and in its future importance, must be considered largely as the product of the physical or geographical conditions by which it has been surrounded.

It does not appear, however, that the operation of these geographic factors is accorded the proper recognition in the study of nations, whatever the guise under which that study is made. Thus, in one of the latest texts at hand, a book designed to complete the course in geography in the schools, a book well thought of generally, widely used, and a fair sample, a half a dozen pages are devoted to the United Kingdom, and less to Germany. A marvelous example, it is, of concentration of facts, but it gives no reasons; no indication of inter-relationship between the nation and its surroundings; no idea or appreciation of the factors which have so closely shaped the whole course of British development; no hint of a real understanding of the nation; it gives simply a collection of statements concerning places and things.

A nation is more than a disorganized array of cities, products and industries. A nation is a living entity: a unit produced by the action of uncompromising physical forces, and its cities, products and industries, at any given time, are but the temporary manifestation of those forces.

The Modifying Factors.—No two nations have been identical in all aspects of their evolution, for no two nations have had identical geographical surroundings. In numerous cases, nations, unlike in important respects, have been composed of people of common origin, as in the case of England and Australia. On the other hand, similarities in physical surroundings have, in every case, produced similarities in development in nations composed of people of different origin, as indicated by Argentine and Australia, or by England and modern Japan. National evolution, therefore, is not a simple question of race, but a more complex question of surroundings and opportunities.

The real understanding of a nation and its evolution depends on an appreciation of the particular combination of physical conditions by which its course has been influenced in the different stages of development. Consequently each nation must be interpreted in terms of its own physical forces, and its strength or weakness may be measured by those forces. The chief physical factors which are important in shaping national development may be grouped, roughly in descending order of importance,[1] under the following general heads: (1) Position with respect to physical relations, (2) position climatically, (3) surface area, (4) surface configuration, (5) productivity of the soil and climate, (6) the possession of potential mechanical energy, (7) mineral wealth.

Physical Position: Separation.—If the conditions necessary for agriculture are assumed to exist, position with respect to physical relations may, on general grounds, be accorded first importance in its effect on national evolution. In the early stages of development of all the older nations, the degree of isolation or separation appears to have been the one significant feature common to all the national territories. This striking similarity may be explained on the ground that unless the primitive group was afforded some degree of protection by natural barriers to attack, the problem of successful establishment and maintenance materially hampered continuity of progress.

A survey of the physical relations surrounding the seats of the early nations of the world indicates the value of separation, since, without exception, they all possessed that quality to a marked degree. Thus, Egypt in the Nile valley, highly favored as it was in soil and climate as a basis for agriculture, may be regarded as owing its early development of national qualities and culture no less to the surrounding desert barrier which guaranteed a large measure of immunity from molestation. For, at the same time, other regions, like the lower Mississippi valley, no less fertile, but lacking protective barriers of any sort, have shown no national development by native groups.

Similar conditions of separation and security were afforded in one way or another in the fertile valleys of western Asia, and in the Greek and Italian peninsulas. Considering Europe as a whole, for example, there are nine fairly distinct physical subdivisions, of which four, the Greek, Italian and Spanish peninsulas and the British Isles, have more or less complete separation, by natural boundaries, from the adjoining continental areas. Each one of the four stands as the seat of solid national development at a date earlier than any stable national existence prevailed in the other parts of the continent, as in the exposed sections occupied by the modern states of Germany and

[1] For any individual nation at some particular stage in its evolution any one of these factors may stand first in importance, as noted later.

Russia. The converse of this argument, therefore, suggests the absence of effective separation for any group as an important factor in the failure of primitive tribes to develop nationally on the open plains of eastern Europe or of South and North America. Sections of the last named, at least, were fully as well favored as was the Nile valley, so far as the prosecution of agriculture is concerned.

The measure of separation not only has been a significant factor in the inception of national development, but also appears as one of the chief modifying influences in all the successive stages of evolution. Its effects have been operative both in the case of older nations developing directly from primitive groups, and in the modification of transplanted national civilizations, of which class the Australian colonies and New Zealand may be regarded as typical. Separation has meant more than the security needed in the period of development from the primitive group into a people solidly welded by national qualities and attributes. Through this same lessened liability of molestation, the more perfect the separation, the greater has been the continuity of social and economic evolution, and the more rapid the advance, beyond the preliminary stages of national existence.

Separation, or the lack of it, also determines the absence or presence of the burden of militarism, and hence fixes the extent to which the energies of the population may be profitably occupied or how much of them must be wasted in unproductive military service. Thus the old Prussian maxim that "Empires are made only by the sword" clearly reflects the exposed position of that state, its dependence on armed strength for its existence, and one of the chief factors in its slow development to important nationality.

The sharply contrasted course of events in England, as compared with either France or Germany, must be explained largely on the degree of separation which has always been one of the chief British assets. The early breaking down of feudalism and serfdom in England and the consequent more rapid advance of personal and political liberty, the freedom from invasion and wars on her own soil, the absence of any powerful rival occupying contiguous territory and the resulting freedom from a great military burden, all represent tremendous advantages, possessed by none of her rivals. All these advantages depended on the separation of England from the continental mainland, by a narrow body of water, the crossing of which was rendered difficult and hazardous by its turbulent waves and currents. France, on the contrary, though in many respects naturally better favored than England, was, by her more exposed position, led into the pursuance of continental policies which frequently involved her in wars on her own soil and greatly hampered internal progress. France thereby was held back at times when England, enjoying internal peace, was forging rapidly ahead. Germany,

more exposed than either of the others, and less distinctly a separate natural unit, was correspondingly slower in her national development, and may still be regarded as existing largely on a military basis.

Separation and Accessibility.—Separation which amounts to isolation, however, is a handicap, rather than a benefit, to the best national progress, for the reason that intercourse with other localities offers opportunity for distinct stimulus through contact with new ideas. To be of maximum value to a nation, therefore, the physical position must afford ready accessibility for peaceful intercourse. For this reason, the character and quality of the national boundaries are in many ways factors of prime importance in the whole course of economic progress and national welfare.

Britain again affords an excellent example. So placed that her doors were effectually closed to serious interference with her internal development, Britain could, however, from her station opposite the convergence of the great European highways of communication, profit readily from intimate contact with continental ideas. History shows that the people of Britain were not the pioneers in commerce, in exploration and discovery, in colonization, or in the development of manufactures: all important lines of activity wherein Britain excelled in later years, and whence came much of the importance of the British nation in the affairs of the world. In each case Britain got the stimulus through her accessibility for peaceful association with continental neighbors, and in each case the superiority of the British position for continuity of internal evolution, readily enabled her to outstrip all others. This same quality of standing somewhat aloof offers a perfectly natural reason for the long-continued preeminence of British influence in the direction of international affairs among the European nations.

China, by contrast, is not to be regarded as a backward nation, because of some inherent lack of ability in her people, but rather as a nation long suffering from too great separation, and consequent lack of new ideas, in much the same way as a single individual, isolated, suffers from lack of stimulus. Japan, much smaller, both in area and in population, and much more readily accessible, shows in her recent rapid developments the effects of intercourse with, and stimulus from, the outside world. China may be expected to show similar results in the future as her greater barriers of isolation are overcome.

Accessibility by Sea.—Ready accessibility from the sea is more important than accessibility by land. It depends on a favorable combination of coast line, surface configuration back of the coast, and climate. Access from the sea means an open route between many nations: a route which is on the whole more easily travelled than the land for the peaceful intercourse of commercial relations, and more

difficult for the movement of a hostile expedition. In this last fact are found the peculiar advantages enjoyed by a country possessing coast boundaries on all sides, like Britain. Without this common, easily travelled, highway, the leading European nations of to-day could not live on their present basis. Access by land alone, along the line of, or even at the convergence of, great natural land routes, such as were so important in the early days of Dutch activity, could not meet the modern demands in the exchange of bulky raw materials for the products of mechanical energy. A list of the countries with no access from the sea is a list of the less important countries of the world, as Bolivia, Switzerland, Servia, Abyssinia, Afghanistan and Thibet. Other countries with seacoasts, but coasts of unsatisfactory character, either because of the absence of good harbors, too great ruggedness of surface, or being ice bound, suffer almost to the same degree, as Peru, and Russia both in Europe and in Asia.

The significance of access from the sea is in one way clearly demonstrated by Russia. During more than two centuries the importance of securing a coast affording ready sea communication at all seasons has been the dominating influence in Russian aggression and territorial expansion. Siberia, with its vast resources, loses most of its value to Russian national development as long as satisfactory outlets to the sea are lacking. The Russo-Japanese war may be regarded as an incident in the long-continued effort to remedy this natural defect. It is not too much to say that the failure of Russia to secure a satisfactory coast and easy access to the common highway of the world accounts for much of the slowness of Russian national evolution, a slowness ordinarily, but wrongly, attributed to the fact that the Russians are of the Slavic, rather than of some other, branch of the Caucasic race.

On the other hand, mere possession of this advantage of a sea coast, avails little unless other conditions are such that it may be used to best profit, as illustrated by the results of the failure of France to utilize, at the dawn of modern commerce, her superior access to the coasts of both Mediterranean Sea and Atlantic Ocean. The reason for this failure must be sought in the weakness of the French position in other directions. For had France enjoyed the internal security and aloofness of England, this direct access to both great commercial highways, backed as it was by the greater size and larger population of the country, the better soil and climate, the natural facilities for internal communication by navigable rivers, and the situation of France with reference to the markets of Europe, would have made France, instead of England, the master of commerce and the leader of all Europe.

The significance of position, therefore, does not cease with the inception of national development, but makes its influence manifest throughout the national existence. In advantages derived from physical posi-

tion, Britain stands close to the ideal, while Germany or Russia may be taken as representative of the opposite extreme.

Position Climatically. Extremes of Climate.—The seats of the early nations of the world, alike in the matter of separation, do not show the same degree of uniformity in climatic characteristics. Their positions climatically, however, do suggest that the extremes of climate are unfavorable to national development. The extremes of cold and of great aridity prohibit cultivation of the soil and thus immediately remove the essential basis of national development. Far northern peoples and desert tribes may utilize their meager opportunities with much greater skill than the most highly civilized man could, hence with respect to their opportunities they are in no sense backward or unprogressive. Yet the burden of satisfying human needs is so great that the people must remain relatively unprogressive and can not develop nationally. They represent a close parallel to the natives of some of the islands of the Pacific Ocean, where the absence of all metals in the coral reefs has prevented a people, highly skilled in many ways, from advancing into a metal age.

The extremes of heat and moisture, when combined, are conducive to the development of extravagant forms of both plant and animal life in superlative abundance. To conquer these rival forms of life and establish himself successfully on an agricultural basis is a difficult task even for the highly civilized man, with every modern appliance at his command. Primitive man, therefore, under these conditions finds himself generally unable to rise above the plane of the forest dweller. At the same time the small need for clothing and shelter, coupled with the ease of gratifying all physical wants from the bounty of nature, favors inaction which is always hostile to progress. For these reasons, national qualities and civilizations have not been developed among the primitive groups of the equatorial rainy sections.

Intermediate Types of Climate.—The intermediate climatic types are the only ones under which national evolution from the primitive group has taken place and where high stages of national civilizations have been developed. In these cases, the climatic conditions impose demands for food, clothing and shelter, beyond the possibilities of the unaided bounty of nature to supply, yet capable of satisfaction through a fair amount of human effort.

This idea of a climatic stimulus as a basis for human progress and the evolution of nations, is commonly expressed in the phrase "spur of the seasons." Too often, however, the spur of the seasons is assumed to mean a winter, or a period when low temperatures cause plant activities to cease temporarily, and therefore require, for the human being, not only the provision of warm clothing and substantial shelter, but also the accumulation of stores of food. This concept

is clearly at variance with the fact that the earliest national developments, of Egypt and western Asia, were in the warmer latitudes, where frosty seasons are absent or not very marked, but where periods of dryness produce conditions in the plant world analogous to the effects of a winter. With the less rigorous, but no less effective, spur of a dry, rather than a cold, season, the fertile protected valleys of the Nile and of the Euphrates naturally developed nations earlier than those localities where the hard conditions of cold winters meant a longer struggle to rise above mere physical needs. The constant operation of this factor of *degree* of rigor in the off season is seen in the successive development of true nationality in the less favored localities, with the least favored advancing slowest of all. Thus the comparatively mild Mediterranean sections of Europe were logical successors of Egypt and western Asia, just as the milder maritime sections of western Europe were the logical predecessors of the more rigorous continental portions, so far as the time of national development was concerned. This climatic factor, therefore, adds another important reason for the slower national evolution in the open plains of north central and eastern Europe, as compared with Britain or France.

Variability of Climate.—Variability of climate may be either periodic, at regular or irregular intervals, or it may be in the nature of apparently permanent change in one direction. Such variation as the latter, whether the change be toward wet, dry, hot or cold, must greatly alter the course of any national evolution already started, as indicated by the evidences of permanent desiccation and consequent depopulation of important sections of the old world. Too much periodic variability of climate, that is, from year to year, or in the form of too long an off season, especially when it is marked by prolonged cold, are almost as great handicaps as the extremes of cold or heat and moisture combined. The unreliability of the Australian climate in practically all the habitable portions, has been, and apparently must be, one of the most important controlling factors in the entire economic development of that country. It is in effect a large scale example of the conditions which brought the Kansas boom, in this country, to a disastrous end two decades ago. The variability of the Indian climate from year to year imposes burdens on the people which hinder greatly the chances for reaching the higher stages in the evolution of India as a nation.

In the same way, too long an off season, particularly a long and cold winter, is a serious obstacle to the best development. Much of the agricultural population of Russia, for example, is forced into idleness through half the year by the length of the Russian winter. Inactivity in itself is hostile enough to progress, but when combined at the same time with the burden of providing against the extreme severities of the long winter, it brings much of Russia close to the border line of those

places where the struggle to meet physical needs consumes every energy. For that reason, the character of the winter may be regarded as another factor constantly tending to retard Russian national evolution.

In many instances the value of the climatic variation from season to season, and especially the effect of the cold season, as a stimulus to regularity of effort is over-estimated. In this country, it is true, the cold winters are, to a certain extent an asset, in that during this period of the year great volumes of clear, dry, pure and invigorating air spread eastward from the northwestern highlands. From these "cold waves" comes stimulation, vigor and energy for many of the American people, yet the duration and intensity of the cold, especially in the more northerly sections, impose heavy burdens on a large part of the population. There is such a thing as too harsh a spur of the seasons. Many a Russian peasant is a chronically jaded creature largely on that account; while in this country, the poor are made poorer because of the increased need for woolen clothing, warmer houses and heavier diet. Though commonly passed over lightly, this question of climatic position is at all times of critical importance in the strength and welfare of nations.

Considered from the broad standpoint, the combined influence of physical position and situation climatically determines whether important national evolution may or may not have its inception and advance successfully under the modifying influences of the other physical factors.

Surface.—The configuration of the surface, to which alone so much significance is usually attached, is a consideration of decidedly secondary importance in the evolution of nations, for the reason that similar surfaces, in different positions, show radically unlike results. Thus a national evolution, may in an inhospitable position remain incapable of type of surface which, when well situated, appears most favorable to any real development. On the other hand, a less desirable type of surface in a more advantageous position may serve as the basis for a fairly important nation. The untouched, level Arctic tundras, and the progress of rugged Norway, may be cited as contrasting examples of the importance of position, both physically and climatically, in considering what the surface qualities are likely to induce.

Surface Area.—In the consideration of the surface and its features, the extent of the surface or the area of the national territory, is of primary significance. The influence of mere size varies in the different stages of evolution. During the first steps of national growth a small or restricted area, other things being favorable, quickly produces a condition of compactness, which is at once a source of strength and a material aid in the advancement of national qualities. The familiar description of Britain as "a tight little island" suggests the way in which British separation was supplemented by restriction of area in

quickly welding diverse racial elements, especially in England, into a strong national unit. Egypt, Assyria, Greece, Rome, in fact all the earlier nations of the world benefited in varying degree from the same important asset of compactness in a restricted area. Russia, on the other hand, is a conspicuous example of the weakness resulting from an absence of that quality, since one of the great problems confronting Russian advance, as a nation, is the unification of her diverse human elements into a national whole. The perpetuation of the present lack of unity is directly traceable to the vastness of area and the consequent lack of common contact. Great size may also include, at the outset, such strongly opposed interests as to hinder or seriously endanger temporarily the permanency of national unity. Thus in both the United States and in Australia the question of differences of climate between the warmer and the colder parts of the national territory introduced issues which threatened to split each nation.

The restriction of area which promotes an early development of national unity and strength is likely, however, to become no less a source of weakness in later stages of evolution. The question of making important, or of perpetuating, a nation hinges on the opportunities available for supplying its population with the primary needs of food, clothing and shelter, and whatever may be required in the shape of utensils and mechanical power. Of these, food, clothing, shelter and utensils depend on the soil and materials to be secured from the earth's crust. Mechanical power alone may be derived elsewhere than from the soil or earth's crust, and power plus human direction may to a certain extent be used to purchase the materials of food, clothing and shelter. But since the greater the area the greater are likely to be the opportunities for supplying all these needs directly, size itself, other things being equal, is always a significant measure of relative strength and permanency of national importance. The relative decline of Holland since 1650, from a position near world leadership to a rank far down in the scale of nations, must be attributed largely to the handicap of small size. Though Holland, as a nation, is now probably more prosperous than ever before in its history, its own physical limitations are too great for it to occupy a leading position among nations.

Here again, Britain serves as an instructive example of the variable effect of size at different times in its national life. Profiting materially in its early days from the fact that it was a "tight little island," that very restriction of area and natural opportunity is now forecasting the relative decline of Britain, no less than the same factor did for Holland two centuries ago. Britain contains at present a population of forty millions in an area less than, and not so richly endowed as, that of the three states of Indiana, Illinois and Iowa; a population living in large part through a process of exchange, which now depends on the

comparatively limited supply of British coal, about two thirds as great as the amount available in Illinois alone. Unless some substitute power can be found as the coal is exhausted, this basis of exchange will no longer exist, and Britain must look forward to a future in which her population will be limited to the number which her small area can feed, clothe and shelter by direct return from her own soil. Making generous estimate of the possibilities of Britain in these respects, it does not appear that more than 75 per cent. of the area, or less than sixty million acres, are capable of any kind of profitable agricultural development.

At present Italy is practically maintaining a population equal to three fourth that of Great Britain from an area of about fifty million cultivated acres. Italy, however, has superior climatic advantages in her favor and the standard of living of her population would, on the whole, probably seem to the Englishman to be inferior to his own. Hence it appears safe to conclude that the area of Britain, without the equivalent of her present mechanical power, could not at best maintain any more than the existing population. Consequently, as other nations, more richly endowed, continue to increase in numbers and in power, the relative decline of Britain would become inevitable, through the changing value of the physical forces which have shaped her course. What applied to Holland in the seventeenth century applies to Britain to-day, and must eventually apply to all the nations of restricted size and no capability of securing relief through the utilization of larger contiguous areas.

Size, then, has exactly opposed values at the two ends of national evolution. The small size which affords strength to, and hastens the development of, the incipient nation, if unchanged, becomes subsequently the weak spot in the foundation on which it must stand. On the other hand, the size, which through its bigness, is likely to retard early development, may become later a source of tremendous strength. The nation with vast area, though perhaps slower in reaching its full development, has not only the basis for ultimate importance, but also the basis for permanent greatness in so far as anything may be regarded as permanent. Thus by virtue of their respective sizes, and what size means, the future course of the United States, of Russia, or of China, must be radically different from the future of Britain, of Germany or of France. The consideration of the area of a nation, therefore, must be carried further than the usual bare statement of so many square miles, and those who ignore the question of size fail to appreciate one of the most significant items in national evolution and strength.

Surface Configuration.—The configuration of the surface is a controlling factor which should perhaps be considered earlier in the dis-

cussion, since it has more or less of a modifying effect on all the preceding factors. It influences climate, favors or hinders the securing of necessities from the soil and the earth's crust, and has much to do with the important question of accessibility, especially by sea. Yet the direct influence of surface configuration by itself on national evolution is, on the whole, less readily traced than in the case of the factors already discussed, for the reason that surfaces practically identical in all important respects may show radically different conditions of development as the result of difference in position, climatic relations and area.

The extremes of configuration, like the extremes of climatic position, are unfavorable to the best national development. Either great diversity, or great monotony of surface are undesirable, but of the two the latter is preferable. Great diversity of surface features, in any except very large areas, may be regarded as the equivalent of prevailing ruggedness, and as a practical barrier to national development on any important scale. The Balkans district of Europe affords the best case in point; a region of decidely irregular contour, it is so completely broken up by more or less effective mountain barriers that ready communication and intimate contact between the people of one part and those of another are not possible. Under such conditions, local interests are greatly magnified, become dominant and the general growth of strong national attributes is unlikely. Great diversity of surface, then, may be said to favor a permanent establishment of the clannish or tribal organization, rather than to promote evolution toward the national state. The effect of surface configuration is shown also in the case of Britain, where the prevailing ruggedness of Scotland and Wales, served, it is true, as a stronghold of defence for refugee natives, but it did not afford the material strength to cope successfully with the more favored and less rugged England. It might even be said that surface features alone made inevitable the domination of all Britain by the people inhabiting the lowlands of England. The combined significance of area and configuration is shown in a contrast of England and Norway, the one, small, moderately diversified, and long important; the other, over twice as large, prevailingly rugged, and never important.

Too great uniformity of surface, amounting to monotony, means little variety of initiative, hence a tendency toward one-sided development. Where variety of surface is lacking, variety of initiative usually depends on one of two factors, first, on the chance location of useful materials in the earth's crust, and second, on sufficient size to produce critical differences in climatic features. In the case of the first factor, however, the discovery and exploitation of the useful materials is, in most cases, distinctly not favored by a uniform surface; and too great contrasts of climate may prove hostile to national solidarity.

When considered from the standpoint of mature nations, however,

the extent of the uniform surface is in large degree the measure of national strength and permanence. Irregular or rugged surfaces, as compared with the uniformity of plains, are naturally less heavily cloaked with soil, and lose that soil much more readily if it is disturbed by cultivation. Furthermore, the rugged surface loses a much larger proportion of its total rainfall through run-off, and for that reason shows more quickly the undesirable effects of scanty precipitation. Hence the more uniform surface is more readily adapted to the production of the necessities of life and is at the same time capable of supplying larger quantities for each unit of area. Assuming, therefore, that the ultimate position of a nation depends mainly on its own ability to produce those things which come directly or indirectly from the soil, it may be said that the strength and permanency of a great nation lies mainly in its agricultural plains.

The ideal configuration of surface, judged with respect to the entire question of national evolution, would include enough diversity to stimulate variety in initiative, and at the same time, a sufficient extent of level area, to give permanent strength in supplying the primary wants of a large population. The United States may well be taken as the nearest approach to this ideal configuration. Estimated on this basis, the great nations of the future will be located on, and derive their strength from, the great plains areas of the world. For that reason one great nation may be expected to appear preeminent in the more favorably situated plains of each of the four major continents.

Productivity of the Soil and Climate.—The importance of the productivity of the soil and climate as one of the factors influencing national evolution has already been implied. Its further consideration, however, is necessary in order to indicate its variable application in the different stages of evolution. Meagerness of returns from a fair amount of human effort, or too great productivity with little or no regularity of effort, do not offer the fundamental conditions necessary for the development of nations, as indicated by the fact that no modern nation has risen to importance without having begun on an agricultural basis. No better evidence of that fact can be found than in the case of Britain and Germany, where to-day agriculture is decidedly secondary, but not very long ago was the main source of national strength. Yet however great importance the agricultural basis may be assumed to have as the foundation of national existence, it must be recognized in the study of individual nations, that beyond the early stages of evolution, the course of events, carrying the nation to the highest rank, may for a time reveal no significant control by the productivity of the soil in its own area.

The unrivaled British supremacy, in practically every respect, in the past century, the commercial and industrial conditions of Germany and of Japan at the present time, furnish examples of national develop-

ment and importance out of proportion, both to the actual use and to the greatest possible productivity of the soil in each of the national areas mentioned. These cases may be taken as typical of a particular stage of development into which some of the nations of to-day have passed naturally, but which the younger nations of the present, as Argentine, Brazil or Canada, can only approach. The stage of development represented by Britain, Germany or Japan depends on the temporary operation of the sixth and seventh physical factors—the possession of potential energy and useful minerals. Later stages, as will be indicated, may very likely bring once more into prominence the influence of the productivity of the soil in the national territory itself.

Potential Energy.—Under the head of potential energy may be grouped all the natural means of developing mechanical power—coal, running water, wind and even the direct rays of the sun. Modern civilization is inseparably associated with the use of two things dependent on potential energy in one form or another: first, the use of heat other than that received direct from the sun; and second, the use of machinery which requires mechanical power either for its making or in its operation. But since heat for any purpose may be secured from mechanical power through the medium of electricity, both needs, for machinery and for heat, hinge on the one question of some single form of potential energy. Coal until recently, at least, has been the one important form of potential energy, for the reason that it furnishes heat directly or supplies power through the medium of steam. These qualities coupled with the possibility of transporting the latent energy to the desired place of utilization, have enabled coal to play perhaps a disproportionate part in directing national development, but its effect may, with some qualification, be taken as indicating the part which mechanical energy, in any form, can play in national evolution.

The value of mechanical power to a nation is best expressed in terms of its equivalent in either animal or man power. One horse power, mechanical energy, may be taken as the equivalent of the power of two average horses or of ten men for a working day of ten hours. A modern steam engine requires not over 2 to 5 pounds of coal for the development of one horse power per hour—a gas engine requires even less—hence a very conservative calculation gives fifty horse power for a working day of ten hours from a single ton of coal. In other words, a ton of coal does in a day the work of at least one hundred horses or of five hundred men. Therefore, one man engaged in mining two tons of coal per day, is producing through the expenditure of one man-power the energy equivalent of a population of 1,000 working men. Calculated on the same basis of values, 80,000 tons of coal produced daily for 300 working days in the year—24,000,000 tons annually—are, in the power they afford, equal to the full energy of a working force

greater than the entire population of Britain. The total British coal production at present—290,000,000 tons yearly—consequently represents a working capacity more than ten times that of the whole population in terms of men, while the annual export of coal from Britain is equal to the emigration of ten million laborers.

Every horse power of available mechanical energy, therefore, should be estimated, not simply as a form of power permitting the use of appliances and processes which neither human nor animal energy could make available, but also as so many added members of the population which do not make any increased demands on the soil for food and the materials of clothing or shelter. The possession of this resource in abundance has, in the past, permitted nations to develop at a rate, or to an extent, which bore no relation to their ability to supply locally the necessities of life: the development instead being on a basis of exchanging the products of their mechanical power for the materials of food and clothing. This existence on a basis of exchange, however, involves the operation of two fundamental conditions. First, the important utilization of power does not appear until national development has passed beyond the stage of scanty population, hence it is logically one of the later stages of evolution. Second, the exchange depends on the existence of other national areas still in the early stages of evolution, not taxing their opportunities to their full capacity, and consequently capable of yielding a surplus of the fundamental necessities of life.

Such excessive development through the operation of one physical factor which temporarily overtops all others, as has resulted from the use of coal in Germany, for example, however strong the nation may appear at the time, is not a safe measure of the true strength and permanence of the nation. It may subsequently be greatly reduced by the natural changing of conditions, for unless the nation possesses in itself some ready substitute for coal when its supply is exhausted, as it inevitably will be exhausted comparatively soon for most nations, that nation must look forward to a future in which there are likely to be necessary certain sharp readjustments, with respect to its ability to take care of its own people. Moreover, as the nations now producing a surplus of necessities continue to advance in their own evolution and trend toward the maximum of their own capacity to feed, clothe and shelter a population, other readjustments, of perhaps even more sweeping character, may be necessary in those places where extensive growth has been based primarily on the means of generating mechanical energy. The stage wherein national importance in industry, commerce and population is derived from resources of coal is in any case transitory, and represents only one step in the gradual adjustment of all nations to their physical surroundings.

Water power in abundance, on the contrary, may be regarded as an

indication of permanent national importance so far as the advantages derived from mechanical energy are concerned; for the reason that, with intelligent management, the power from running water may be depended on as long as rain continues to fall. Here, however, it is necessary to recall the significance of climatic position, size and surface configuration, since available water power, except in special cases, is the component result of the total quantity of water falling on the land and the proportion of it which runs off through the streams, determined largely by the configuration of the surface. Under the accepted desirable conditions of medium and reliable climatic values, the rainfall on any considerable area would be adequate and sufficiently uniform with respect to the supply in the different seasons of the year. Hence, size of the area and configuration of the surface take on added importance, in that they largely determine the possibilities of water-power development. Both small areas and monotonous uniformity of surface become less desirable, for the reason that in flat regions the fall of the rivers and the condition of their banks do not favor ready or extensive power development; and a small area, whatever its surface, means small actual quantity of water falling on it. Consequently the moderate degree of surface diversity is not simply more desirable through its relation to variety of initiative, but, because of its relation to water power, may be regarded as second in importance only to the conditions permitting agriculture.

For illustration Britain again serves the purpose best, since Britain has for two centuries stood at the forefront of the nations of the world, has developed in a restricted area a large population existing on the basis of exchanging the products of power for the necessities of life, and has, in that development, depended for power almost entirely on a limited supply of coal. Furthermore, Britain is confronted by the realization that the time is not far distant when that coal supply will begin to fail. The question is, therefore, will the small area of Britain with its medium rainfall and moderate diversity of surface offer the means of replacing the steam power now used by power from running water, and through that water power make it possible to maintain, on the existing basis, a population which in the past has increased at the rate of nearly half a million annually? Britain must do that or else be confronted by one of two conditions: either a static population, such as France has exhibited in recent decades; or a declining population due to inability any longer to support the number.

From the standpoint of the power of running water available on the land, the question for Britain probably must be answered in the negative. For example, the average yearly rainfall for Britain, as a whole, is distinctly less than 36 inches; but accepting that figure, for the sake of generosity, and estimating the surface run-off at the high value of

40 per cent. of the total fall, the gross discharge through surface drainage per year from the entire area of Britain is equal only to about one fifth the annual discharge of the Mississippi River system. All of the streams in Britain have the major part of their courses where the land is well under an altitude of 1,000, an elevation less than that of most of the Mississippi drainage basin. In the streams of the latter system the available water power has been estimated to be as high as 25,000,000 horse power. Calculated on the same basis, and in terms of their total discharge, the maximum power capacity of the British streams would not exceed 5,000,000 horse power, which, even if increased by 50 per cent., to give a generous estimate because of the shorter and more rapid descent of some of the British streams, falls far short of meeting the present British needs for mechanical energy. Hence, the dependence of Britain on her streams for power would mean not merely the inability to take care of an increasing population, but also an actual lessening of her ability to support, as at present, the numbers already existing.

This amount of power from streams, however, might be materially supplemented by the utilization of energy in the rise and fall of the ocean waters in the tides, the feasibility of which, under favorable conditions, has already been demonstrated at different places along the coast of this country. Here once more the position of Britain, its size and configuration, are decidedly favorable for the development and general use of such wave and tidal power; practically every locality in the kingdom being so situated as to be able to benefit from its use under the present condition of transmission of power over wires in the form of electricity. Estimates of the extent to which energy of the tides can be utilized for commercial purposes are still largely conjecture, since the need for turning to that source of power has not yet risen, but it seems not unlikely that the future of Britain is to depend, perhaps more closely than ever, on those same physical factors which have been so significant in practically every chapter in the past—her insular position, compactness and configuration of the coast.

Germany, on the other hand, confronted by the same problem of coal exhaustion, has a less hopeful outlook because of her different surroundings. Germany with a large and rapidly increasing population, already grown well beyond the food capacity of the national area, recognizes the necessity for providing for her increasing numbers by increasing commercial and industrial activity—all dependent on mechanical energy. In this respect Germany is less favored than Britain, not only as regards coal,[2] but also as regards water power to replace coal. Calculated on the basis of an average rainfall of 30 inches and a run-off of 40 per cent., both of which figures are high, the total

[2] The actual quantity is estimated to be a little larger in Germany, but so much of it is lignite that it has distinctly less industrial value.

discharge of the German rivers is not above one fourth that of the Mississippi system, as contrasted with one fifth for Britain. Greater ruggedness of surface marks a part of the German territory, but on the other hand, a very large part of the drainage area of the chief streams lies in the North German plain at altitudes under 600 feet, as unfavorable for power development as they have been favorable to river navigation. At the best, therefore, the German streams could hardly be counted on for more than 10,000,000 horse power, or again less than the amount of mechanical energy actually employed at present. The position of Germany offers little prospect for the use of power from the sea on any such important scale as seems feasible in Britain, and other likely sources of water power do not appear to afford the necessary relief. The future of Germany seems, therefore, to present a case in which the question of power and a stage of evolution arising from its use is likely to involve readjustments of a far-reaching character.

The contrast of these two examples, Britain and Germany, may serve to illustrate the extent to which permanent natural sources of mechanical power are factors for national strength, second in importance only to the capacity of the soil to produce food, since under favorable circumstances both afford a solid basis for large national development. It must be recognized, however, that in assuming a logical and permanent stage of evolution based on the possession of power alone, it is necessary to take into account the likelihood of there always being some areas so endowed as to produce surplus necessities of life, while they, or other areas, are unable from their own surroundings to satisfy their needs for the products of power.

Mineral Wealth.—The part played by one sort of mineral supply, in national development, has been indicated in the discussion of coal as a source of energy. With respect to the products of the mines in general and particularly if the term be liberally interpreted, to include all inorganic products of the earth, it may be said that they as a group represent one of the most important of physical factors in the modern progress of nations. Leaving coal entirely aside, it still remains true that the tremendous development of every phase of modern industry, from the cultivation of the soil to the most complex manufacturing process, has become possible only through the constantly increasing employment of mineral products. In fact, the critical difference between the nations of to-day and those of the past is found in the present dependence on materials won from the earth's crust; and it might almost be said that the nations rank to-day and will in the future continue to rank in direct proportion to the wealth of their mineral resources.

The question needs, however, to be considered carefully, since some

minerals, popularly accorded great importance, are of distinctly minor significance in their effects on national evolution and strength, and especially since many mineral supplies must be considered as more or less temporary. Gold and silver must be classed among the mineral resources of lesser importance, whatever the merits of their relations to national currency systems, for the reason that they serve man's needs but little when compared with iron, copper or even humble clay products, and consequently their effect on national evolution has been correspondingly less. Gold and silver, it is true, induce men to live where they otherwise would not be found in any large numbers, as in the cold wastes of Alaska and the desert of Australia, but such populations are rarely important or stable. Gold and silver, moreover, when given in exchange, may help to buy necessities for a nation, but all the world's annual output of gold would barely pay for the raw cotton purchased from this country yearly. A nation like Germany, for example, poverty-stricken in its gold and silver deposits, has advanced greatly in every respect in the last forty years despite its necessity of buying food, during the same time that a country like Australia, one of the leading gold localities of the world, has had but unimportant progress. In practically no nation has the possession of the so-called precious metals been a leading, or permanent, determining factor in development.

On the other hand, the use of stone and clay products in providing shelter, and the use of clay or the baser metal products in providing utensils, tools and the like, have lifted a burden from the soil and allowed more of it to be devoted to the production of the materials of food and clothing. They have also at the same time, through their application in machinery, made it possible to produce food and clothing on a far greater scale.

The existing scale of dependence on mineral supplies, however, implies a rate of consumption likely to exhaust any but the richest or most extensive accumulations at no very distant date, considered in terms of historical periods. Hence, once more it appears that restricted area and their limited natural opportunities are of critical significance in the evolution of nations. For such areas as Britain and Germany, already populated to the limit of soil capacity, with little prospect of expanding their power resources, and not over-stocked with supplies of the minerals which are essential to so many branches of industry, the future holds little or no prospect for further sound national growth. Such nations are to be regarded as having reached practically the culminating point in their evolution, with their future likely to be marked by the gradual adjustment of economic conditions to the permanent opportunities for supporting a population.

Conclusions.—It appears, therefore, that three general conclusions

may be drawn from this discussion. First, each nation should be regarded as following a regular life course of definite ages, in which it is influenced at all times by the combined effect of the geographical factors of its environment. Second, from the proper valuation of these controlling factors it is possible in any stage of evolution to measure the real strength of a nation. Finally, every nation will arrive eventually at a stage where its physical surroundings set a limit to further development, materially, though not necessarily in culture. It may be expected that each nation as it arrives at this later stage in its existence will exhibit the spectacle of a static population, and such a nation may be said to have attained its full maturity—that is a condition of practically perfect adjustment between national opportunity and national development. France may be taken as an example of a nation which has reached, earlier than any of the others, this stage of full maturity.

It may even be that in individual cases, as perhaps in Germany and Japan, the temporary operation of one or two factors, as coal and some useful minerals, have already induced a condition of development which will necessitate subsequent readjustments, even to the point of actual decadence. A parallel condition might also arise through the misuse and consequent destruction of those national opportunities which should be permanent, as through soil erosion and the destruction of water power by deforestation. Wherever, by one means or the other, the basis for maintaining the national existence is materially lessened or destroyed, the nation must be regarded as old, or physically decadent, having exhausted the forces with which it was naturally endowed, just as in the old age of the human being, it is the breaking down of the individual physical endowment which marks the decline.

This inevitable adjustment of the nations of the world to their environments seems to call for relative decadence, like that of Holland since 1650, on the part of many nations holding a more or less prominent place to-day, especially so in the case of those of small area and restricted opportunity: and a corresponding rise, both relative and absolute, in most of the large units, which, in most cases, are still in the early, or young stages of their national evolution. In this latter group Russia, perhaps, is the most striking example, while the United States is somewhat farther along toward the stage of maturity: it might be described as having passed its adolescence and beginning to feel its strength, while Russia has still to reach the adolescent stage of youth. Thus the great nation of to-day may in one case be the great nation of to-morrow; in another case not. The real measure of fitness lies in the relation of each individual nation to the physical factors by which its evolution and its strength are determined.

THE DYNAMICS OF A GOLF BALL[1]

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THERE are so many dynamical problems connected with golf that a discussion of the whole of them would occupy far more time than is at my disposal this evening. I shall not attempt to deal with the many important questions which arise when we consider the impact of the club with the ball, but confine myself to the consideration of the flight of the ball after it has left the club. This problem is in any case a very interesting one, it would be even more interesting if we could accept the explanations of the behavior of the ball given by many contributors to the very voluminous literature which has collected round the game; if these were correct, I should have to bring before you this evening a new dynamics, and announce that matter when made up into golf balls obeys laws of an entirely different character from those governing its action when in any other condition.

If we could send off the ball from the club, as we might from a catapult, without spin, its behavior would be regular, but uninteresting; in the absence of wind its path would keep in a vertical plane, it would not deviate either to the right or to the left, and would fall to the ground after a comparatively short carry.

But a golf ball when it leaves the club is only in rare cases devoid of spin, and it is spin which gives the interest, variety and vivacity to the flight of the ball. It is spin which accounts for the behavior of a sliced or pulled ball, it is spin which makes the ball soar or "douk," or execute those wild flourishes which give the impression that the ball is endowed with an artistic temperament, and performs these eccentricities as an acrobat might throw in an extra somersault or two for the fun of the thing. This view, however, gives an entirely wrong impression of the temperament of a golf ball, which is in reality the most prosaic of things, knowing while in the air only one rule of conduct, which it obeys with unintelligent conscientiousness, that of always following its nose. This rule is the key to the behavior of all balls when in the air, whether they are golf balls, base balls, cricket balls or tennis balls. Let us, before entering into the reason for this rule, trace out some of its consequences. By the nose of the ball we mean the point on the ball furthest in front.

[1] A lecture given before the Royal Institution of Great Britain.

Thus if, as in Fig. 1, C the center of the ball is moving horizontally to the right, A will be the nose of the ball; if it is moving horizontally to the left, B will be the nose. If it is moving in an inclined direction CP, as in Fig. 2, then A will be the nose.

Now let the ball have a spin on it about a horizontal axis, and suppose the ball is travelling horizontally, as in Fig. 3, and that the

FIG. 1.

direction of the spin is as in the figure, then the nose A of the ball is moving upwards, and since by our rule the ball tries to follow its nose, the ball will rise and the path of the ball will be curved as in the dotted line. If the spin on the ball, still about a horizontal axis, were in the opposite direction, as in Fig. 4, then the nose A, of the ball, would be moving downwards, and as the ball tries to follow its

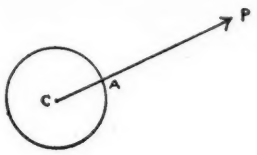


FIG. 2.

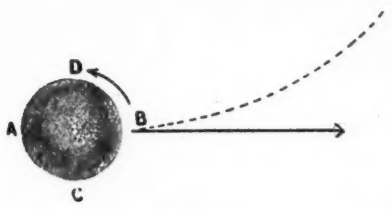


FIG. 3.

nose it will duck downwards, and its path will be like the dotted line in Fig. 4.

Let us now suppose that the ball is spinning about a vertical axis, then if the spin is as in Fig. 5, as we look along the direction of the flight of the ball the nose is moving to the right; hence by our rule the ball will move off to the right, and its path will resemble the dotted

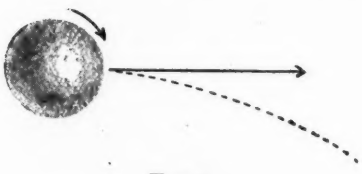


FIG. 4.

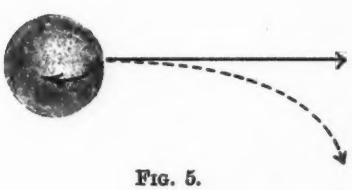


FIG. 5.

line in Fig. 5, in fact, the ball will behave like a sliced ball. Such a ball, as a matter of fact, has spin of this kind about a vertical axis.

If the ball spins about a vertical axis in the opposite direction as in Fig. 6, then, looking along the line of flight, the nose is moving to

the left, hence the ball moves off to the left, describing the path indicated by the dotted line; this is the spin possessed by a "pulled" ball.

If the ball were spinning about an axis along the line of flight, the axis of spin would pass through the nose of the ball, and the spin would not affect the motion of the nose; the ball following its nose would thus move on without deviation.

FIG. 6.

Thus, if a cricket ball were spinning about an axis parallel to the line joining the wickets, it would not swerve in the air, it would, however, break in one way or the other after striking the ground; if, on the other hand, the ball were spinning about a vertical axis, it would swerve while in the air, but would not break on hitting the ground. If the ball were spinning about an axis intermediate between these directions it would both swerve and break.

Excellent examples of the effect of spin on the flight of a ball in the air are afforded in the game of base ball; an expert pitcher by putting on the appropriate spins can make the ball curve either to the right or to the left, upwards or downwards; for the sideway curves the spin must be about a vertical axis, for the upward or downward ones about a horizontal axis.

A lawn-tennis player avails himself of the effect of spin when he puts "top spin" on his drives, *i. e.*, hits the ball on the top so as to make it spin about a horizontal axis, the nose of the ball traveling downwards, as in Fig. 4; this makes the ball fall more quickly than it otherwise would, and thus tends to prevent it going out of the court.

Before proceeding to the explanation of this effect of spin I will show some experiments which illustrate the point we are considering. As the forces acting on the ball depend on the *relative* motion of the ball and the air, they will not be altered by superposing the same velocity on the air and the ball; thus, suppose the ball is rushing forward through the air with the velocity V, the forces will be the same if we superpose on both air and ball a velocity equal and opposite to that of the ball; the effect of this is to reduce the center of the ball to rest, but to make the air rush past the ball as a wind moving with the velocity V. Thus, the forces are the same when the ball is moving and the air at rest, or when the ball is at rest and the air moving. In lecture experiments it is not convenient to have the ball flying about the room, it is much more convenient to keep the ball still and make the air move.

The first experiment I shall try is one made by Magnus in 1852; its object is to show that a rotating body moving relatively to the air

is acted on by a force in the direction in which the nose of the body is moving relatively to its center; the direction of this force is thus at right angles, both to the direction in which the center of the body is moving, and also to the axis about which the body is spinning.

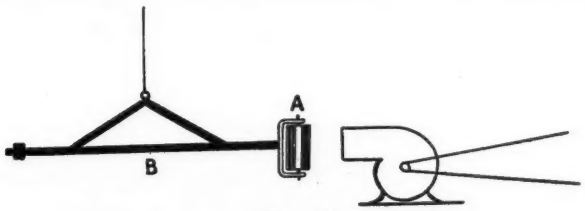


FIG. 7.

For this purpose a cylinder *A* (Fig. 7) is mounted on bearings so that it can be spun rapidly about a vertical axis; the cylinder is attached to one end of the beam *B*, which is weighted at the other end, so that when the beam is suspended by a wire it takes up a horizontal position. The beam yields readily to any horizontal force, so that if the cylinder is acted on by such a force, this will be indicated by the motion of the beam. In front of the cylinder there is a pipe *D*, through which a rotating fan driven by an electric motor sends a blast of air which can be directed against the cylinder. I adjust the beam and the beam carrying the cylinder, so that the blast of air strikes the cylinder symmetrically; in this case, when the cylinder is not rotating the impact against it of the stream of air does not give rise to any motion of the beam. I now spin the cylinder, and you see that when

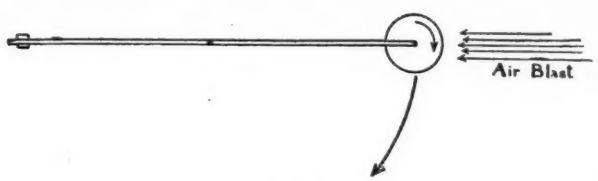


FIG. 8.

the blast strikes against it the beam moves off sideways. It goes off one way when the spin is in one direction, and in the opposite way when the direction of spin is reversed. The beam, as you will see, rotates in the same direction as the cylinder, which an inspection of Fig. 8 will show you is just what it would do if the cylinder were acted upon by a force in the direction in which its nose (which, in this case, is the point on the cylinder first struck by the blast) is moving. If I stop the blast, the beam does not move even though I spin the cylinder, nor does it move when the blast is in action if the rotation of the cylinder is stopped; thus both spin of the cylinder and movement of it through the air are required to develop the force on the cylinder.

Another way of showing the existence of this force is to take a pendulum whose bob is a cylinder, or some other symmetrical body, mounted so that it can be set in rapid rotation about a vertical axis. When the bob of the pendulum is not spinning the pendulum keeps swinging in one plane, but when the bob is set spinning the plane in which the pendulum swings no longer remains stationary, but rotates slowly in the same sense as the bob is spinning (Fig. 9).

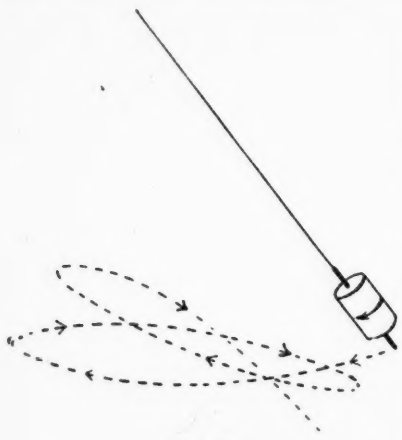


FIG. 9.

We shall now pass on to the consideration of how these forces arise. They arise because when a rotating body is moving through the air the pressure of the air on one side of the body is not the same as that on the other: the pressures on the two sides do not balance, and thus the body is pushed away from the side where the pressure is greatest.

Thus, when a golf ball is moving through the air, spinning in the direction shown in Fig. 10, the pressure on the side *ABC*, where the velocity due to the spin conspires with that of translation, is greater than that on the side *ADB*, where the velocity due to the spin is in the opposite direction to that due to the translatory motion of the ball through the air.

I will now try to show you an experiment which proves that this is the case, and also that the difference between the pressure on the two sides of the golf ball depends upon the roughness of the ball.

FIG. 10.

In this instrument, Fig. 11, two golf balls, one smooth and the other having the ordinary bramble markings, are mounted on an axis, and can be set in rapid rotation by an electric motor. An air-blast produced by a fan comes through the pipe *B*, and can be directed against the balls; the instrument is provided with an arrangement by which the supports of the axis carrying the balls can be raised or lowered so as to bring either the smooth or the bramble-marked ball opposite to the blast. The pressure is measured in the following way: *LM* are two tubes connected with the pressure-gauge *PQ*; *L* and *M* are placed so that the golf balls can just fit in between them; if the pressure of the air on the side *M* of the balls is greater than that of the side *L* the liquid on the right-hand side *Q* of the pressure-gauge will be depressed; if, on the other hand,

the pressure at L is greater than that at M the left-hand side P of the gauge will be depressed.

I first show that when the golf balls are not rotating there is no difference in the pressure on the two sides when the blast is directed

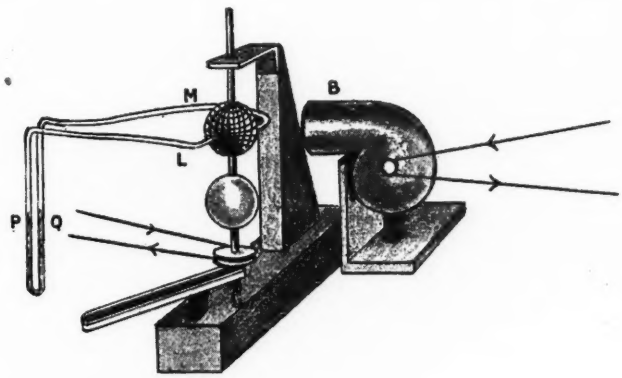


FIG. 11.

against the balls; you see there is no motion of the liquid in the gauge. Next I stop the blast and make the golf balls rotate; again there is no motion in the gauge. Now when the golf balls are spinning in the direction indicated in Fig. 11, I turn on the blast, the liquid falls on the side Q of the gauge, rises on the other side. Now I reverse the direction of rotation of the balls, and you see the motion of the liquid in the gauge is reversed, indicating that the high pressure has gone from one side to the other. You see that the pressure is higher on the side M where the spin carries this side of the ball into the blast, than on L where the spin tends to carry the ball away from the blast. If we could imagine ourselves on the golf ball, the wind would be stronger on the side M than on L, and it is on the side of the strong wind that the pressure is greatest. The case when the ball is still and the air moving from right to left is the same from the dynamical point of view as when the air is still and the ball moves from left to right; hence we see that the pressure is greatest on the side where the spin makes the velocity through the air greater than it would be without spin.

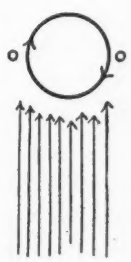


FIG. 12.

Thus, if the golf ball is moving, as in Fig. 12, the spin increases the pressure on the right of the ball, and diminishes the pressure on the left.

To show the difference between the smooth ball and the rough one, I bring the smooth ball opposite the blast; you observe the difference between the levels of the liquid in the two arms of the gauge. I now

move the rough ball into the place previously occupied by the smooth one, and you see that the difference of the levels is more than doubled, showing that with the same spin and speed of air blast the difference of pressure for the rough ball is more than twice that for the smooth.

We must now go on to consider why the pressure of the air on the two sides of the rotating ball should be different. The gist of the explanation was given by Newton nearly 250 years ago. Writing to Oldenburg in 1671 about the dispersion of light, he says, in the course of his letter, "I remembered that I had often seen a tennis-ball struck with an oblique racket describe such a curved line. For a circular as well as progressive motion being communicated to it by that stroke, its parts on that side where the motions conspire must press and beat the contiguous air more violently, and there excite a reluctancy and reaction of the air proportionately greater." This letter has more than a scientific interest—it shows that Newton set an excellent precedent to succeeding mathematicians and physicists by taking an interest in games. The same explanation was given by Magnus, and the mathematical theory of the effect is given by Lord Rayleigh in his paper on "The Irregular Flight of a Tennis Ball," published in the *Messenger of Mathematics,* Vol. VI., p. 14, 1877. Lord Rayleigh shows that the force on the ball resulting from this pressure difference is at right angles to the direction of motion of the ball, and also to the axis of spin, and that the magnitude of the force is proportioned to the velocity of the ball multiplied by the velocity of spin, multiplied by the sine of the angle between the direction of motion of the ball and the axis of spin. The analytical investigation of the effects which a force of this type would produce on the movement of a golf ball has been discussed very freely by Professor Tait, who also made a very interesting series of experiments on the velocities and spin of golf balls when driven from the tee and the resistance they experience when moving through the air.

FIG. 13.

As I am afraid I can not assume that all my hearers are expert mathematicians, I must endeavor to give a general explanation without using symbols, of how this difference of pressure is established.

Let us consider a golf ball, Fig. 13, rotating in a current of air flowing past it. The air on the lower side of the ball will have its motion checked by the rotation of the ball, and will thus in the neighborhood of the ball move more slowly than it would do if there were no golf ball present, or than it would do if the golf ball were there but was not spinning. Thus if we consider a stream of air flowing along the channel *PQ,* its velocity when near the ball at *Q*

must be less than its velocity when it started at P; there must, then, have been pressure acting against the motion of the air as it moved from P to Q, *i. e.*, the pressure of the air at Q must be greater than at a place like P, which is some distance from the ball. Now let us consider the other side of the ball: here the spin tends to carry the ball in the direction of the blast of air; if the velocity of the surface of the ball is greater than that of the blast, the ball will increase the velocity of the blast on this side, and if the velocity of the ball is less than that of the blast, though it will diminish the velocity of the air, it will not do so to so great an extent as on the other side of the ball. Thus the increase in pressure of the air at the top of the ball over that at P, if it exists at all, will be less than the increase in pressure at the bottom of the ball. Thus the pressure at the bottom of the ball will be greater than that at the top, so that the ball will be acted on by a force tending to make it move upwards.

We have supposed here that the golf ball is at rest, and the air rushing past it from right to left; the forces are just the same as if the air were at rest, and the golf ball rushing through it from left to right. As in Fig. 13, such a ball rotating in the direction shown in the figure will move upwards, *i. e.*, it will follow its nose.

It may perhaps make the explanation of this difference of pressure easier if we take a somewhat commonplace example of a similar effect. Instead of a golf ball, let us consider the case of an Atlantic liner, and, to imitate the rotation of the ball, let us suppose that the passengers are taking their morning walk on the promenade deck, all circulating round the same way. When they are on one side of the boat they have to face the wind, on the other side they have the wind at their backs. Now when they face the wind, the pressure of the wind against them is greater than if they were at rest, and this increased pressure is exerted in all directions, and so acts against the part of the ship adjacent to the deck; when they are moving with their backs to the wind, the pressure against their backs is not so great as when they were still, so the pressure acting against this side of the ship will not be so great. Thus the rotation of the passengers will increase the pressure on the side of the ship when they are facing the wind, and diminish it on the other side. This case is quite analogous to that of the golf ball.

The difference between the pressures on the two sides of the golf ball is proportional to the velocity of the ball multiplied by the velocity of spin. As the spin imparted to the ball by a club with a given loft is proportional to the velocity with which the ball leaves the club; the difference of pressure when the ball starts is proportional to the square of its initial velocity. The difference between the average pressures on the two sides of the ball need only be about one fifth of

one per cent. of the atmospheric pressure to produce a force on the ball greater than its weight. The ball leaves the club in a good drive with a velocity sufficient to produce far greater pressures than this. The consequence is that when the ball starts from the tee spinning in the direction shown in Fig. 14, this is often called underspin, the upward force due to the spin is greater than its weight, thus the resultant force is upwards, and the ball is repelled from the earth instead of being attracted to it. The consequence is that the path of the ball curves upward, as in the curve *A*, instead of downwards, as in *B*, which would be its path if it had no spin. The spinning golf ball is in fact a very efficient heavier than air flying machine, the lifting force may be many times the weight of the ball.

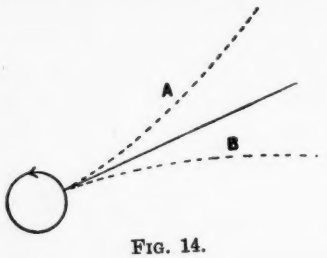


FIG. 14.

The path of the golf ball takes very many interesting forms as the amount of spin changes. We can trace all these changes in the arrangement which I have here, and which I might call an electric golf links. With this apparatus I can subject small particles to forces of exactly the same type as those which act on a spinning golf ball.

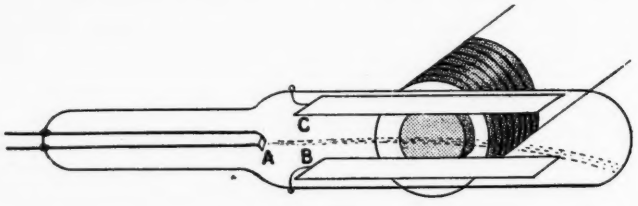


FIG. 15.

These particles start from what may be called the tee *A* (Fig. 15). This is a red hot piece of platinum with a spot of barium oxide upon it, the platinum is connected with an electric battery which causes negatively electrified particles to fly off the barium and travel down the glass tube in which the platinum strip is contained; nearly all the air has been exhausted from this tube. These particles are luminous, so that the path they take is very easily observed. We have now got our golf balls off from the tee, we must now introduce a vertical force to act upon them to correspond to the force of gravity on the golf ball. This is easily done by the horizontal plates *BC*, which are electrified by connecting them with an electric battery; the upper one is electrified negatively, hence when one of these particles moves between the plates it is exposed to a constant downwards force, quite analogous to the weight of the ball. You see now when the particles pass between the plates their path has the shape shown in Fig. 16;

this is the path of a ball without spin. I can imitate the effect of spin by exposing the particles while they are moving to magnetic force, for the theory of these particles shows that when a magnetic force acts upon them, it produces a mechanical force which is at right angles to the direction of motion of the particles, at right angles also to the magnetic force and proportional to the product of the

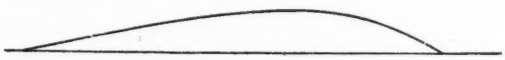


FIG. 16.

velocity of the particles, the magnetic force and the sine of the angle between them. We have seen that the force acting on the golf ball is at right angles to the direction in which it is moving at right angles to the axis of spin, and proportional to the product of the velocity of the ball, the velocity of spin and the sine of the angle between the velocity and the axis of spin. Comparing these statements you will see that the force on the particle is of the same type as that on the golf

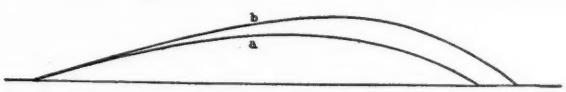


FIG. 17.

ball if the direction of the magnetic force is along the axis of spin and the magnitude of the force proportional to the velocity of spin, and thus if we watch the behavior of these particles when under the magnetic force we shall get an indication of the behavior of the spinning golf ball. Let us first consider the effect of underspin on

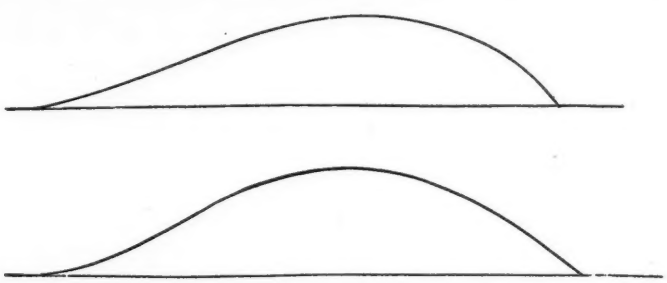


FIG. 18.

the flight of the ball: in this case the ball is spinning, as in Fig. 3, about a horizontal axis at right angles to the direction of flight. To imitate this spin I must apply a horizontal magnetic force at right angles to the direction of flight of the particles. I can do this by means of the electromagnet. I will begin with a weak magnetic force, representing a small spin. You see how the path differs from

the one when there was no magnetic force; the path, to begin with, is flatter though still concave, and the carry is greater than before—see Fig. 17, *a*. I now increase the strength of the magnetic field, and you will see that the carry is still further increased, Fig. 17, *b*. I increase the spin still further, and the initial path becomes convex instead of

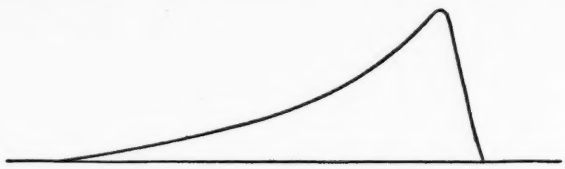


FIG. 19.

concave, with a still further increase in carry, Fig. 18. Increasing the force still more, you see the particle soars to a great height, then comes suddenly down, the carry now being less than in the previous case (Fig. 19). This is still a familiar type of the path of the golf ball. I now increase the magnetic force still further, and now we get a type

FIG. 20.

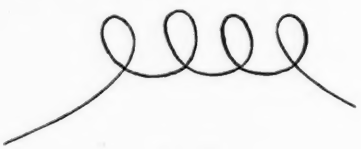


FIG. 21.

of flight not to my knowledge ever observed in a golf ball, but which would be produced if we could put on more spin than we are able to do at present. You see there is a kink in the curve, and at one part of the path the particle is actually traveling backwards (Fig. 20). Increasing the magnetic force I get more kinks, and we have a type

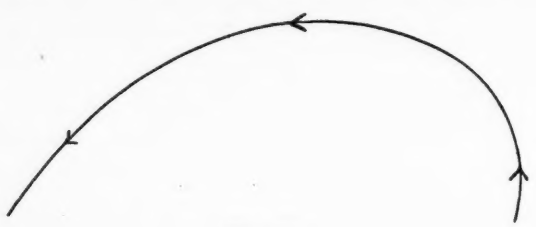


FIG. 22.

of drive which we have to leave to future generations of golfers to realize (Fig. 21).

By increasing the strength of the magnetic field I can make the curvature so great that the particles fly back behind the tee, as in Fig. 22.

So far I have been considering underspin. Let us now illustrate slicing and pulling; in these cases the ball is spinning about a vertical axis. I must therefore move my electromagnet, and place it so that it produces a vertical magnetic force (Fig. 23). I make the force act

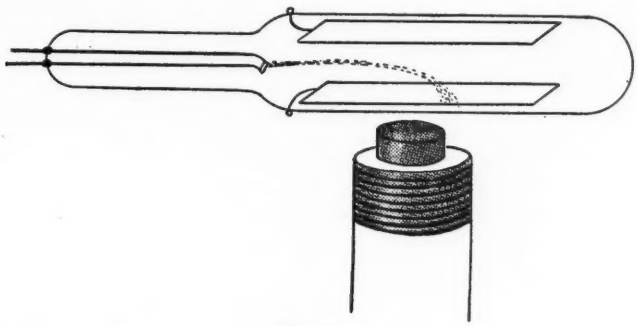


FIG. 23.

one way, say downwards, and you see the particles curve away to the right, behaving like a sliced ball. I reverse the direction of the force and make it act upwards, and the particles curve away to the left, just like a pulled ball.

By increasing the magnetic force we can get slices and pulls much more exuberant than even the worst we perpetrate on the links.

Though the kinks shown in Fig. 20 have never, as far as I am aware, been observed on a golf links, it is quite easy to produce them if we use very light balls. I have here a ball *A* made of very thin india-rubber of the kind used for toy balloons, filled with air, and weighing very little more than the air it displaces; on striking this

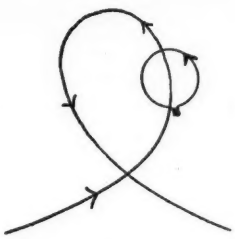


FIG. 24.

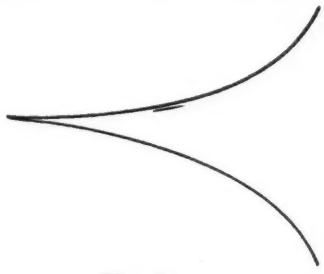


FIG. 25.

with the hand, so as to put underspin upon it, you see that it describes a loop, as in Fig. 24.

Striking the ball so as to make it spin about a vertical axis, you see that it moves off with a most exaggerated slice when its nose is moving to the right looking at it from the tee, and with an equally pronounced pull when its nose is moving to the left.

One very familiar property of slicing and pulling is that the curvature due to them becomes much more pronounced when the velocity of the ball has been reduced, than it was at the beginning when the velocity was greatest. We can easily understand why this should be so if we consider the effect on the sideways motion of reducing the velocity to one half. Suppose a ball is projected from A in the direction AB, but is sliced; let us find the sideways motion BC due to slice. The sideways force is, as we have seen, proportional to the product of the velocity of the ball and the velocity of spin, or if we keep the spin the same in the two cases, to the velocity of the ball; hence, if we halve the velocity we halve the sideways force, hence, in the same time the displacement would be halved too, but when the velocity is halved the time taken for the ball to pass from A to B is doubled. Now the displacement produced by a constant force is proportional to the square of the time; hence, if the force had remained constant, the sideways deflection BC would have been increased four times by halving the velocity, but as halving the

FIG. 26.

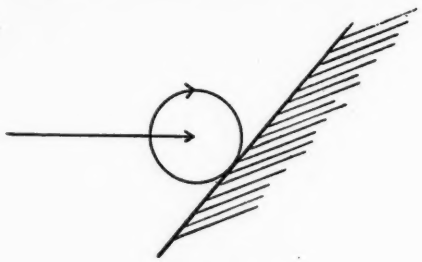


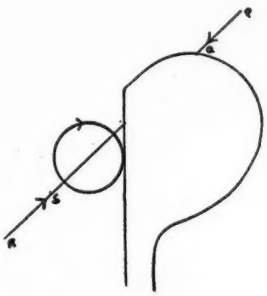
FIG. 27.

velocity halves the force, BC is doubled when the velocity is halved; thus the sideways movement is twice as great when the velocity is halved.

If the velocity of spin diminished as rapidly as that of translation the curvature would not increase as the velocity diminished, but the resistance of the air has more effect on the speed of the ball than on its spin, so that the speed falls the more rapidly of the two.

The general effect of wind upon the motion of a spinning ball can easily be deduced from the principles we discussed in the earlier part of the lecture. Take, first, the case of a head-wind. This wind increases the relative velocity of the ball with respect to the air; since the force due to the spin is proportional to this velocity, the wind increases this force, so that the effects due to spin are more pronounced when there is a head-wind than on a calm day. All golfers must have had had only too many opportunities of noticing this. Another illustration is found in cricket; many bowlers are able to swerve when bowling against the wind who can not do so to any considerable extent on a calm day.

Let us now consider the effect of a cross-wind. Suppose the wind is blowing from left to right, then, if the ball is pulled, it will be rotating in the direction shown in Fig. 26; the rules we found for the effect of rotation on the difference of pressure on the two sides of a ball in a blast of air show that in this case the pressure on the front half of the ball will be greater than that on the rear half, and thus tend to stop the flight of the ball. If, however, the spin was



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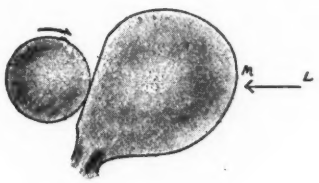


FIG. 29.

that for a slice, the pressure on the rear half would be greater than the pressure in front, so that the difference in pressure would tend to push on the ball and make it travel further than it otherwise would. The moral of this is that if the wind is coming from the left we should play up into the wind and slice the ball, while if it is coming from the right we should play up into it and pull the ball.

I have not time for more than a few words as to how the ball acquires the spin from the club. But if you grasp the principle that the

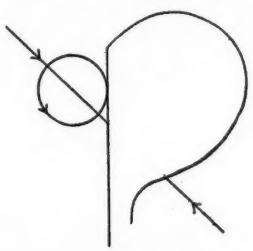


FIG. 30.

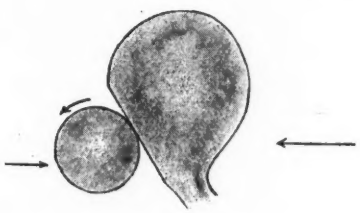


FIG. 31.

action between the club and the ball depends only on their *relative* motion, and that it is the same whether we have the ball fixed and move the club, or have the club fixed and project the ball against it, the main features are very easily understood.

Suppose Fig. 27 represents the section of the head of a lofted club moving horizontally forward from right to left, the effect of the impact will be the same as if the club were at rest and the ball were shot

against it horizontally from left to right. Evidently, however, in this case the ball would tend to roll up the face, and would thus get spin about a horizontal axis in the direction shown in the figure; this is underspin, and produces the upward force which tends to increase the carry of the ball.

Suppose, now, the face of the club is not square to its direction of motion, but that looking down on the club its line of motion when it strikes the ball is along *PQ* (Fig. 28), such a motion as would be produced if the arms were pulled in at the end of the stroke, the effect of the impact now will be the same as if the club were at rest and the ball projected along *RS*, the ball will endeavor to roll along the face away from the striker; it will spin in the direction shown in the figure about a vertical axis. This, as we have seen, is the spin which produces a slice. The same spin would be produced if the motion of the club were along *LM* and the face turned so as to be in the position shown in Fig. 29, *i. e.*, with the heel in front of the toe.

If the motion and position of the club were as in Figs. 30 and 31, instead of as in Figs. 28 and 29, the same consideration would show that the spin would be that possessed by a pulled ball.

THE PROGRESS OF SCIENCE

SCIENTIFIC MEETINGS AT MINNEAPOLIS AND ELSEWHERE

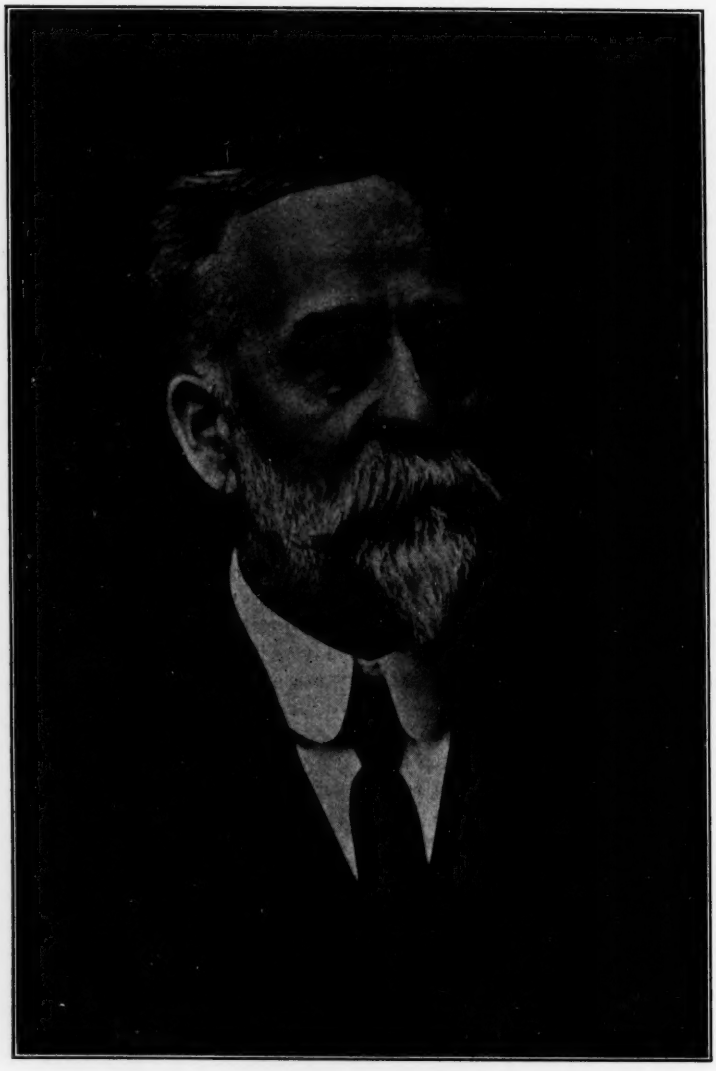
THE convocation week meeting of the American Association for the Advancement of Science and the affiliated scientific societies was held this year at Minneapolis beginning on the evening of December 27. The attendance of scientific men was in the neighborhood of 1,200, which is about half as large as at the recent meetings in eastern cities. Although the number of men of science in the central states is continually increasing, and the center of scientific population will soon coincide with the center of the general population, Minneapolis is in the far northwest of the region, and it is a considerable railway journey from the seats of other universities. It is well known that the distance from the east to the west is psychologically longer than the reverse. There were at Minneapolis about a hundred scientific men from the eastern seaboard.

The chemists had as usual the largest attendance and the most extensive program. Next came the zoologists and botanists. The geologists had a competing meeting elsewhere; the anthropologists did not meet, and the section of social and economic science had a very small attendance. The national societies devoted to these subjects and to engineering do not meet with the association and it is difficult to decide what should be done in such cases. Probably the best solution is to have no program of special papers, but to plan one or two sessions of general interest, such as the papers on aviation arranged this year by the officers of the section of mechanical science and engineering.

The number of papers on the program to be presented before each section of the association or the corresponding affiliated societies was as follows:

Mathematics and astronomy	34
Physics	40
Chemistry	178
Mechanical science and engineering	21
Geology and geography	24
Zoology	122
Botany	81
Anthropology and psychology	41
Social and economic science	8
Physiology and experimental medicine	13
Education	30
Total	592

At the opening session the retiring president, Dr. David Starr Jordan—distinguished equally as a zoologist, a university president, an advocate of peace and in other good causes—after introducing the president of the meeting, Professor A. A. Michelson, of the University of Chicago—one of the most eminent of living men of science—gave his address, entitled "The Making of a Darwin." Dr. Jordan argued that the fundamental elements in the making of an investigator are the original material, to which we may look to heredity alone; meeting nature at first hand and meeting her early and persistently, and the personal inspiration and enthusiasm derived from some great teacher. It was refreshing to hear a university president characterize at their true value the machinery and paraphernalia of the modern university. Perhaps the address was not so judicial as might have been expected in view of the double office held by the speaker, but it was none the less interesting on that account. The group of zoologists drawn to the Johns Hopkins



DR. CHARLES E. BESSEY,
President of the American Association for the Advancement of Science.

University in its earlier years largely by fellowships and using laboratory methods of investigation will bear comparison better than Dr. Jordan seems to think with the earlier group of naturalists of the school of Agassiz.

The addresses of the vice-presidents of the association maintained high standards and were in most cases of general interest. Thus Professor Minot, of Harvard, treated the method of science; Professor Brown, of Yale, the relation of Jupiter with the asteroids; Dr. Bauer, of the Carnegie Institution, research in terrestrial magnetism; Professor McPherson, of Ohio State University, the production of carbohydrates in plants; Director Brock, of the Canadian Geological Survey, northern Canada, and Professor Ritter, of the University of California, mechanism and vitalism. The addresses before the special societies and the discussions and papers of more than ordinary interest can not even be mentioned by title in a short note.

Dr. Charles E. Bessey, professor of botany at the University of Nebraska, dean and on several occasions acting president, distinguished for his contributions to science and for establishing in a western university a center of botanical teaching and research whose influence has extended over the whole country, was elected president of the American Association to preside over the meeting to begin at Washington on December 27, 1911.

While the American Association and a large group of national scientific societies were meeting at Minneapolis, other societies were meeting elsewhere. At Ithaca the American Society of Naturalists under the presidency of Dr. D. T. MacDougal had an interesting program devoted to problems of experimental evolution. With them met the eastern zoologists and the bacteriologists. The geologists, geographers and paleontologists met in Pittsburgh, the physiologists at New Haven, the mathematicians in New York and the anthropologists in Providence. There are scientific and social advantages both in a large convocation-week gathering of all men of science and in smaller meetings of groups devoted to a single science. Probably the best results are obtained by adopting different plans on different occasions.

THE UNIVERSITY OF MINNESOTA

THERE are at least three objects attained by attendance at scientific meetings. The papers and discussions are the official occasion, and are certainly of importance. They exhibit contemporary and common interests in a way that is not otherwise possible, and they often serve as a stimulus to research work both before and after the meeting. Of scarcely less consequence are the personal acquaintances and renewed friendships. The third advantage of migratory meetings is the opportunity to visit different parts of the country and to see their scientific and educational institutions. The more distant the place of meeting, the more interesting they are likely to be. So men of science are repaid for their journeys in direct proportion to their length.

A long trip would be well rewarded by the opportunity to see the University of Minnesota. The development of our state universities is probably the most significant movement in higher education, and nowhere are the opportunities and problems exhibited on a more comprehensive scale than in Minnesota. The adjacent states of Michigan, Illinois, Wisconsin and Minnesota possess four of our greatest universities. For many years Michigan led the way; more recently Wisconsin has made the most rapid advances both in the standards reached in its faculties and in its influence in the state. Illinois and Minnesota, established later, are now likely to press forward in friendly rivalry for leadership. The state of Illinois has two private universities—one of them

FOLWELL HALL, THE COLLEGE BUILDING.

rivaling Harvard and Columbia in its endowments and standards—which will continue to share with the state institution the educational leadership of the state. Minnesota has no competition; and its situation in a large city and adjacent to the capital of the state gives it certain advantages, especially for its professional schools. It has been more fortunate than other state universities in retaining possession of its land grants and in finding them to be the site of vast mineral resources. Most of all it is happy in the possession of a population of high character and intelligence.

Historians are likely to describe the epochs of a country's history under the reigning sovereigns, whether these personages have played a significant or an insignificant part in its affairs. Universities are in like manner known by the administrations of their successive presidents.

Dr. W. W. Folwell was in charge during the infancy of the University of Minnesota, from 1869 to 1884. Dr. Cyrus Northrop has in truly patriarchal fashion guided its vigorous youth. Almost his last official act was to welcome the scientific societies to Minneapolis. Dr. G. E. Vincent, professor of sociology in the University of Chicago, active in its educational management and in the Chautauqua movement inaugurated by his father, now assumes the presidency. It is difficult to exaggerate the possibilities of the development of the university during his administration.

All the buildings now on the campus have been erected within the past twenty-five years. In spite of or on account of their varying and somewhat naïve styles of architecture they make a pleasing impression. Folwell Hall, the headquarters for the scientific societies, is a building admirably constructed for class work. Chemistry, physics and the natural sciences have satisfactory buildings, though it is planned to replace or alter them. Extensive groups of buildings are to be erected for the engineering and medical departments. The university has not as yet made use of its posi-

THE LIBRARY.

MAIN BUILDING OF THE SCHOOL OF AGRICULTURE.

tion on a bluff overlooking the Mississippi, but plans have been drawn to remodel the entire arrangement of the buildings with a view to taking advantage of its fine site.

Land, buildings and equipment, students and teachers in large numbers, the university will surely have. It is now a big university and will become much bigger. Whether it will become one of the great universities of the world will depend on whether it can find great men for its chairs. This is the question before all our universities: it should be the dominant concern of Minnesota at the present time.

SCIENTIFIC ITEMS

PRESIDENTS of the national scientific societies have been elected as follows: The American Society of Naturalists, Professor H. S. Jennings, of the Johns Hopkins University; The American Chemical Society, Professor Alexander Smith, of the University of Chicago; The Botanical Society of America, Professor W. G. Farlow, of Harvard University; The Geological Society of America, Professor W. M. Davis, of Harvard University; The Association of American Geographers, Professor Ralph S. Tarr, of Cornell University; The American Paleontological Society, Professor William B. Scott, of Princeton University; The Society of Biological Chemists, Professor L. B. Mendel, of Yale University; The American Anthropological Association, Dr. J. Walter Fewkes, of the Bureau of American Ethnology; The American Psychological Association, Professor C. E. Seashore, University of Iowa; the American Philosophical Association, Professor Frederick J. E. Woodbridge, of Columbia University.

THE Nobel prizes, amounting to about $40,000 each, have been distributed by the King of Sweden with the usual ceremonies. The prize-winners in science—Professors Van der Waals (physics), Wallach (chemistry) and Kossel (medicine)—were present to receive their prizes and give the statutory lectures.